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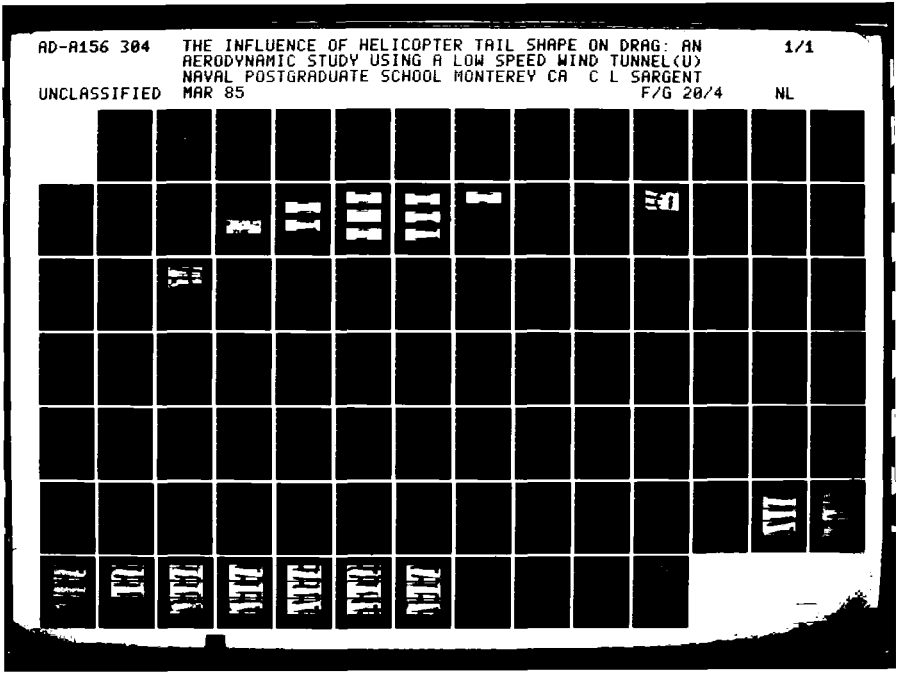

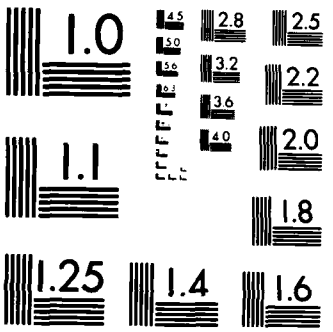

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

THE INFLUENCE OF HELICOPTER TAIL SHAPE ON DRAG
AN AERODYNAMIC STUDY
USING A LOW SPEED WIND TUNNEL

by

Christopher L. Sargent

March 1985

Thesis Advisor: Donald M. Layton

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- This thesis examines the effect of helicopter tail shape on drag using a low speed wind tunnel at the Naval Postgraduate School. A modification to the Aeronautical Engineering Department's 3.5' x 5' wind tunnel was made

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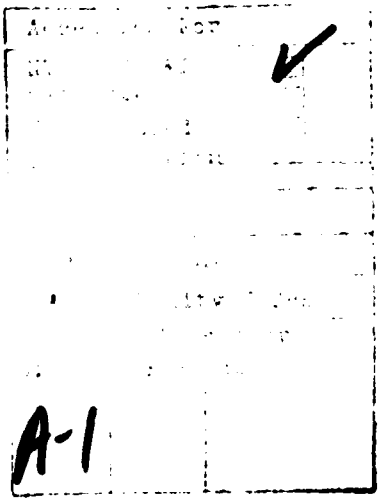

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The Influence of Helicopter Tail Shape on Drag An Aerodynamic Study Using a Low Speed Wind Tunnel

by

Christopher L. Sargent
Captain, United States Army
B.S., United States Military Academy, 1974

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
March 1985

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Dean of Science and Engineering

ABSTRACT

This thesis examines the effect of helicopter tail shape on drag using a low speed wind tunnel at the Naval Postgraduate School. A modification to the Aeronautical Engineering Departments' 3.5'x 5' wind tunnel was made to update the facilities and allow this work. Major R. Scott Mair worked simultaneously to study the effect of nose shape on drag, a result of the 2-man requirement for wind tunnel work. The existing external balance was replaced with an internal balance and a variable angle-of-attack support system was constructed as well. Quantitative data was collected with this balance, and qualitative information was obtained by tufting the models and visualizing the airflow. The equipment built was adequate with the exception of one component of the balance, which will require a new balance to be built. This single deficiency was significant enough to invalidate the output of the balance and as a result any quantitative discussion of how a helicopter's tail shape affects drag. Without this data the explanation of drag, using flow visualization alone is also not practical.

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ACKNOWLEDGEMENTS

To Ron Ramaker for his artistic effort in crafting a superb model and Bob Besel for his technical advice and time taken in procuring all the required hardware. To Glenn Middleton for his precise machine work and patient understanding in the process, and Ted Dunton for his sage advice so well needed when seen in retrospect. Their advice, experience, and humor was invaluable and made this project truly enjoyable.

I. INTRODUCTION

A. COORDINATION OF EFFORT

Successful and safe operation of a wind tunnel project requires at least two people in full-time involvement, either the investigator and an assistant/technician, or co-investigators. Inasmuch as this was an unfunded project, there was no full-time technician available and, as a result, a coordinated effort was conducted with the thesis project of another Master of Science in Aeronautical Engineering student, Major Mair [Ref. 1].

Even though a deliberate effort was made to separate the majority of functions in the two projects, e.g., design of the test and calibration equipment - Mair and design of the models, sting support, and balance - Sargent, when two people work closely together, much of the output is the result of proposals and counter-proposals, and their contributions are difficult to distinguish.

The differences, however, in the scope and outcomes of the experiment dictate that the results of these efforts, no matter how great the coordination, be presented as two separate theses.

B. BACKGROUND

Although exhaustive analyses of helicopter drag have been made, aerodynamic modelling has not been an area of concentration at the Naval Postgraduate School. However, determination of both qualitative and quantitative fuselage drag parameters is an essential part of the education process, and, in particular, is a valuable adjunct to helicopter design courses.

Previously, quantitative data at the Naval Postgraduate School low-speed wind tunnels were obtained with 'external' balance systems placed outside the tunnel and measurements were made through struts passing through the tunnel floor to the model. Not only was this

technique dated, none of the balance systems worked properly and in order to make precise measurements it was necessary to borrow a balance from the NASA Ames Research Laboratory. This not only inhibited continuing work in this area, but in addition, the risk of loss or damage to the NASA system was intolerable.

It was decided that an 'internal' balance that could be located inside the model would not only provide the information required for the project at hand, but, if designed with a universal mount, such a balance could be used for other fixed and rotary wing models. And, if such a balance could be constructed at low cost (this being an unfunded project), it would provide the Department of Aeronautics with an in-house capability that did not currently exist.

Such a balance was designed by the author, with the aid of a Russian design [Ref. 2: pp. 412-414], constructed by the Department of Aeronautics, and installed in the 3.5' x 5' Aerolab wind tunnel in Building 234 at the Naval Postgraduate School.

C. QUALITATIVE DATA

Although a properly designed wind tunnel balance can provide quantitative information as to lift, drag and moments, such information may not be enough to fully explain what is causing these forces and moments. A flow visualization technique that would permit a qualitative examination of the potential field about the model would be a welcome addition to a modelling process, but if this visualization process did not produce interference forces on the model, such a qualitative examination would be extremely worthwhile.

Such an advanced technique was available through the use of 'Mini-tufting' [Ref. 3]. The nearly microscopic strands of fluorescent monofilament line are permanently mounted on the surface of the model and do not interfere with force measurements.

D. QUANTITATIVE DATA

A variable angle-of-attack sting system was designed that would permit pitch rotation about both the center of the balance and the center of the model. This system was mounted in the wind tunnel with provisions for external control of the angle-of-attack. The balance and the model were supported by this sting system.

E. GOALS

The primary purpose of this project was to produce a helicopter wind tunnel model, balance system and instrumentation that could provide experimental data to be used by students in the helicopter design classes for the development of realistic Equivalent Flat Plate area information for several types of helicopters.

Secondary purposes established during the conduct of the project included the development of a two-axis internal wind tunnel balance with a universal mount and the addition of flow visualization to the quantitative determinations.

II. APPROACH TO THE PROBLEM

A. MODEL DESIGN

1. *Concept*

To provide a selection of fuselage shapes for comparison, three noses and three tails were chosen representing existing as well as more advanced technologies in helicopter design. The author prepared planviews (Figures A.1-A.5) from which the nose and tail sections were made. To make comparisons of lift and drag between these nine model combinations, and yet not introduce too many variables, the concept of a fuselage, common to each combination was also designed by the author and built (Figure A.6). To this each nose and tail could be mounted, each with the same cross-sectional shape and mounting system (Figure 2.1)

Figure 2.1 Common Fuselage with Nose and Tail Sections

2. *Shapes*

By first considering one nose, and then evaluating the effect of each of the three tails , a comparison of tail shapes could be made. This was done for each of the noses for a total of nine model combinations (Figures 2.2-2.10).

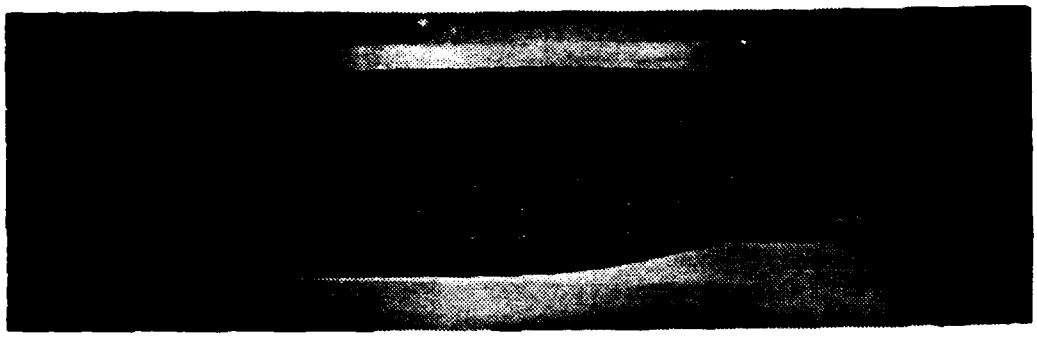


Figure 2.2 Attack Nose with High Tail

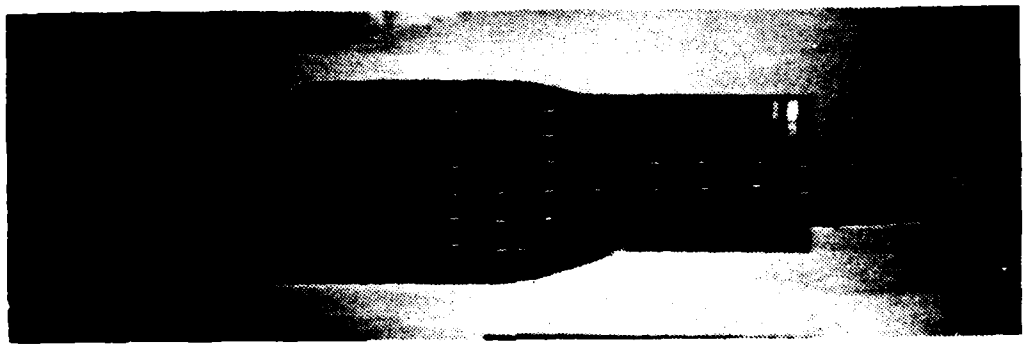


Figure 2.3 Attack Nose with Symmetric Tail

3. *Construction*

All parts of the model were constructed of aluminium and wood with screws and bolts used as fasteners. The center fuselage is a rigid box of metal with metal end plates and a filling of wood to form

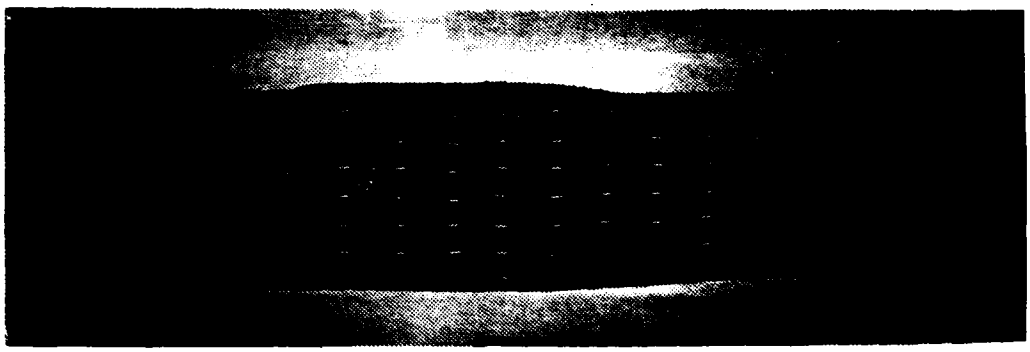


Figure 2.4 Attack Nose with Low Tail

Figure 2.5 Blunt Nose with High Tail

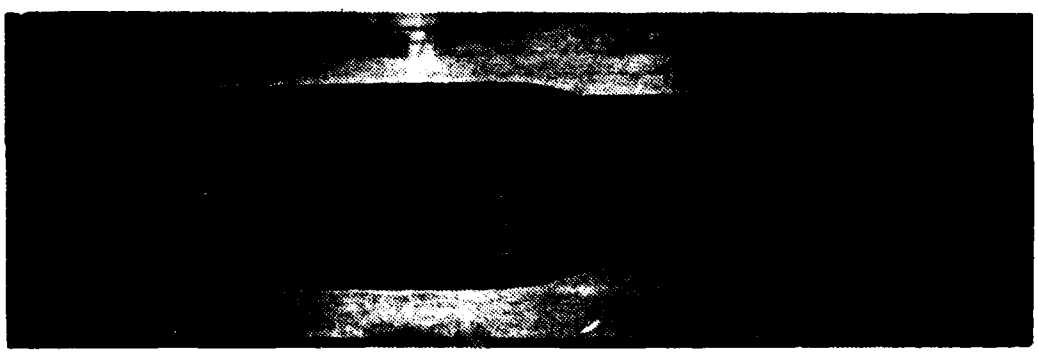


Figure 2.6 Blunt Nose with Symmetric Tail

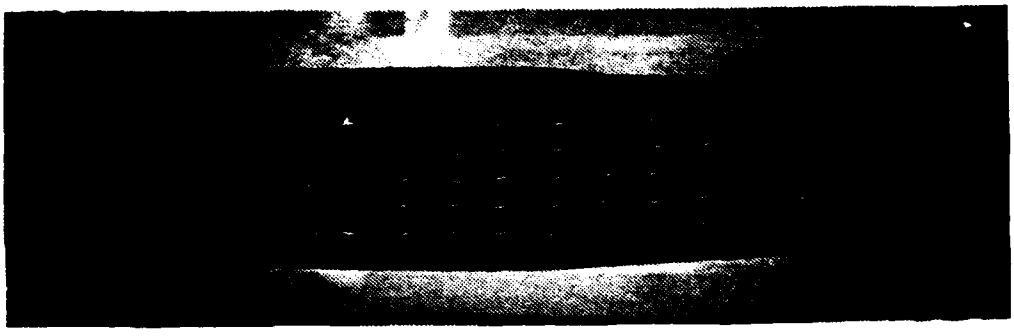


Figure 2.7 Blunt Nose with Low Tail

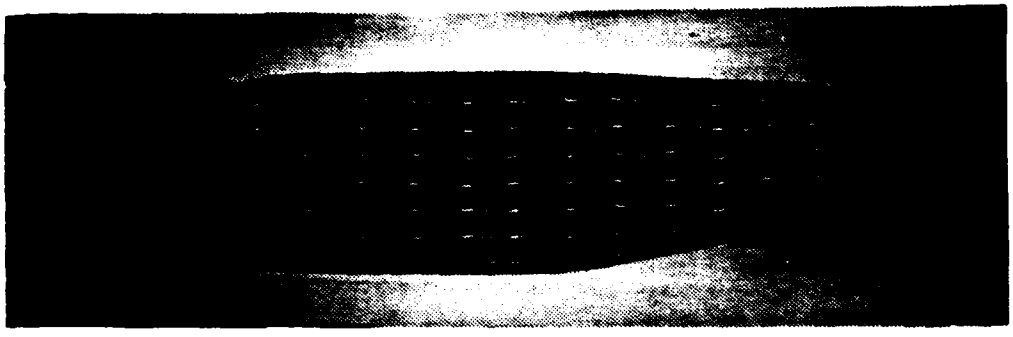


Figure 2.8 Smooth Nose with High Tail

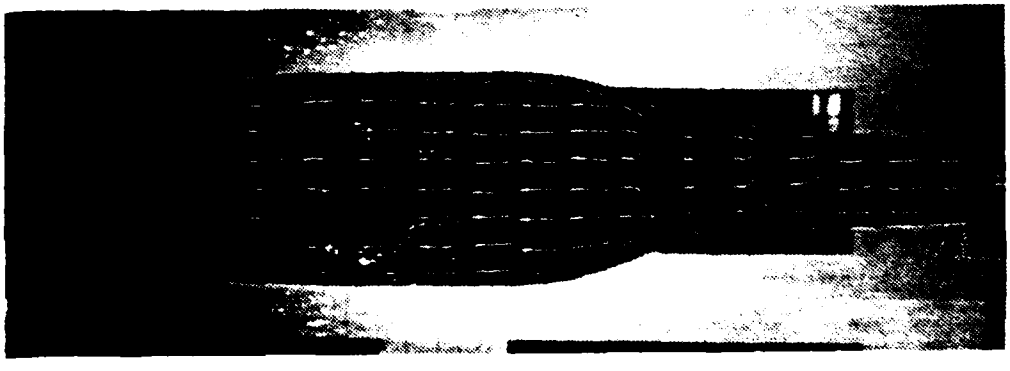


Figure 2.9 Smooth Nose with Symmetric Tail

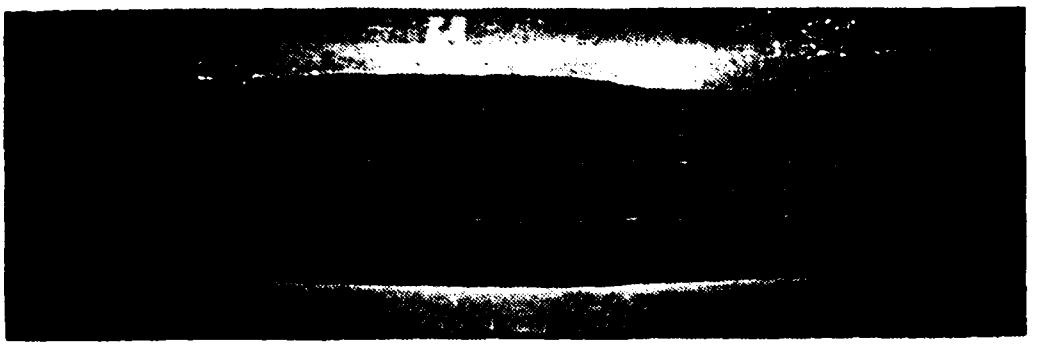


Figure 2.10 Smooth Nose with Low Tail

the skin. Three bars of metal run the length of each side of the common fuselage to form a screw-in mounting for landing gear, wing stores supports, etc., for future expansion. The noses and tails are wood, for the most part, and have metal end plates for a uniform joining surface.

B. WIND TUNNEL MODIFICATION

1. *Tunnel Design*

Figure 2.11 shows the wind tunnel used in the Aeronautical Engineering Department. The external balance used previously (Figure 2.12) was dismantled and the floor of the test section replaced for the sting support system (Figure 2.13). This was designed by the author, a planview of which is included in Figure A.7 This support to which the balance is mounted, fixes the center of the balance in space (and therefore the pitching axis of the model) and allows for an angle of attack change of +10 to -12 degrees.

2. *Test Section Environment*

Tests were made for cross-sectional wind tunnel velocity and angularity at the location of the model in the tunnel. A cross-sectional mapping of velocity produced a very uniform distribution of velocity.

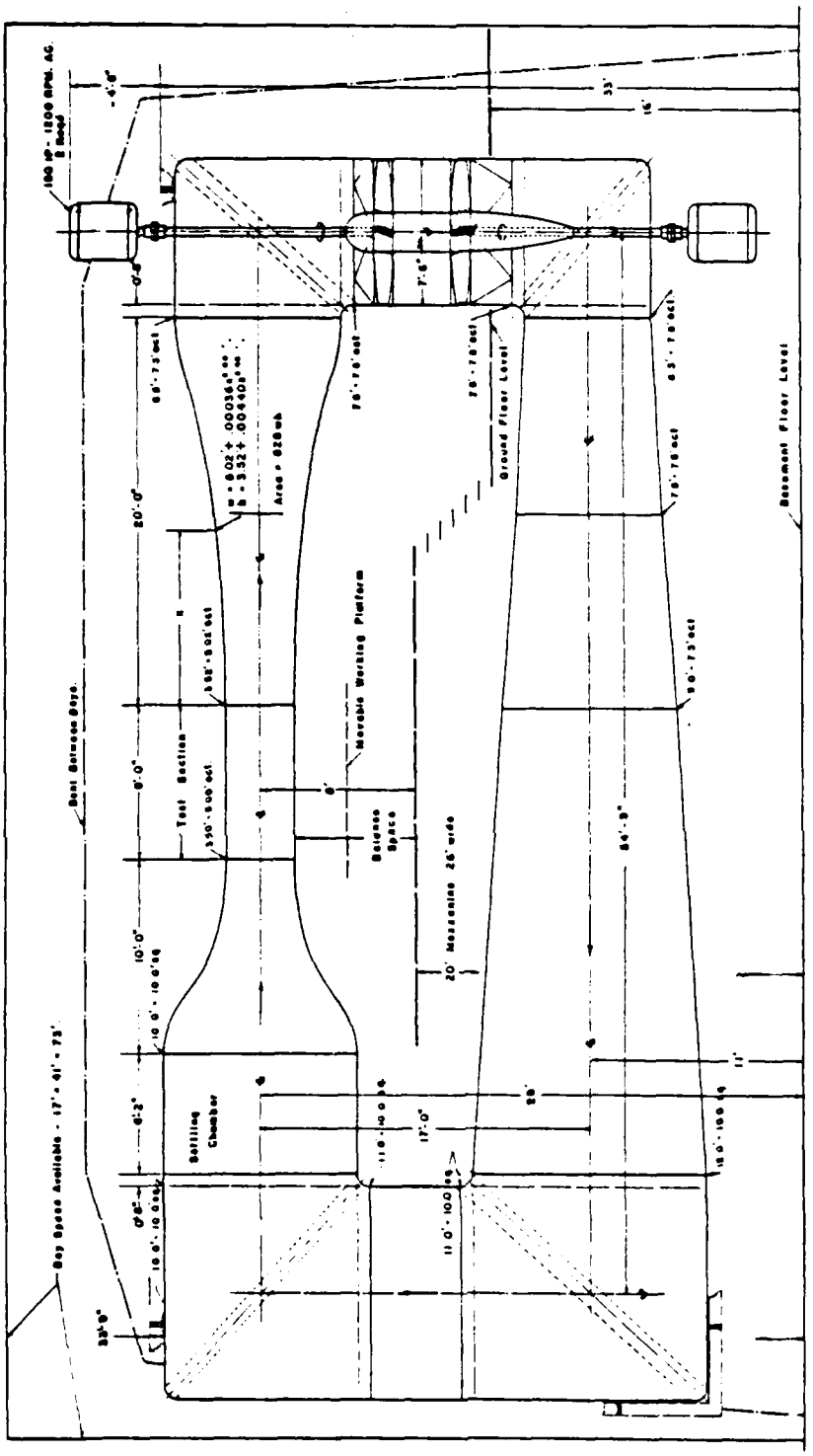
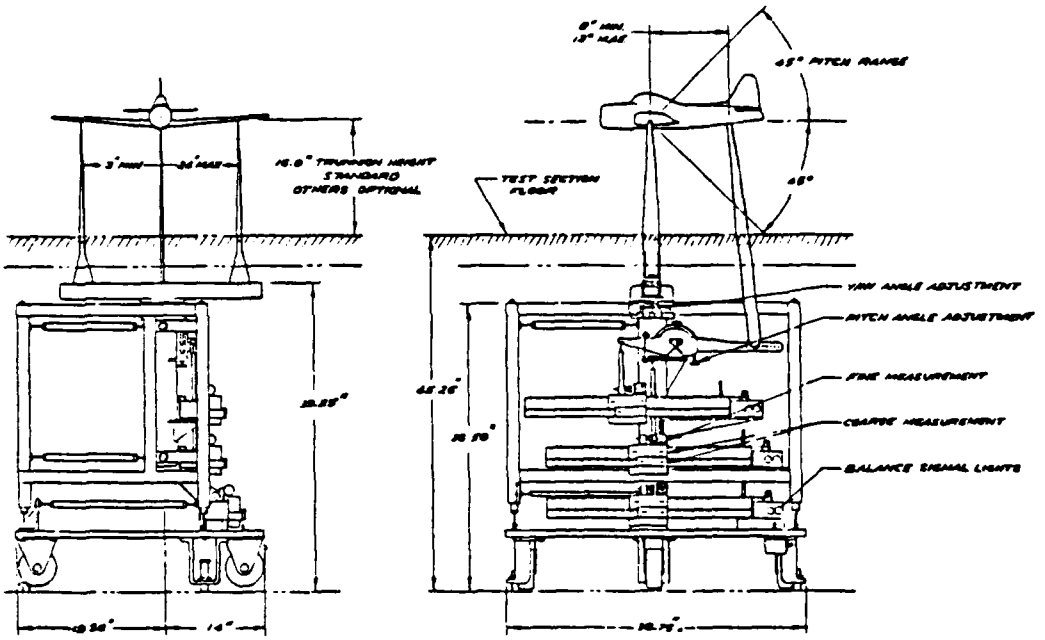


Figure 2.11 3.5 x 5 foot Low Speed Wind Tunnel



AEROLAB 3 COMPONENT BEAM BALANCE

Figure 2.12 Preexisting External Balance

This distribution was made by running a pitot static probe across the tunnel from each of the eight tunnel walls, creating a 'spider web', that effectively mapped the cross-sectional area. Measuring the angularity, or twist, of the flow was done by attaching a yaw probe to the traversing system used for measuring velocity. This gave a map (Figure 2.14) of the angularity as viewed from upwind looking into the test section for dynamic pressures of 20, 30, and 40 psf. The tunnel initially had two counter-rotating sets of blades, eliminating most of the twist in the flow, but one set had been previously damaged and could not be repaired. This produced a flow with more angularity then desired. Twist was severe at the tunnel walls, but was moderate in the vicinity of the model location. Because only trends were being compared, and each model was affected similarly, the effects of angularity were not corrected. A further reason for neglecting the influence of this flow was that planar surfaces such as wings or tails that would have been noticeably affected were not used.

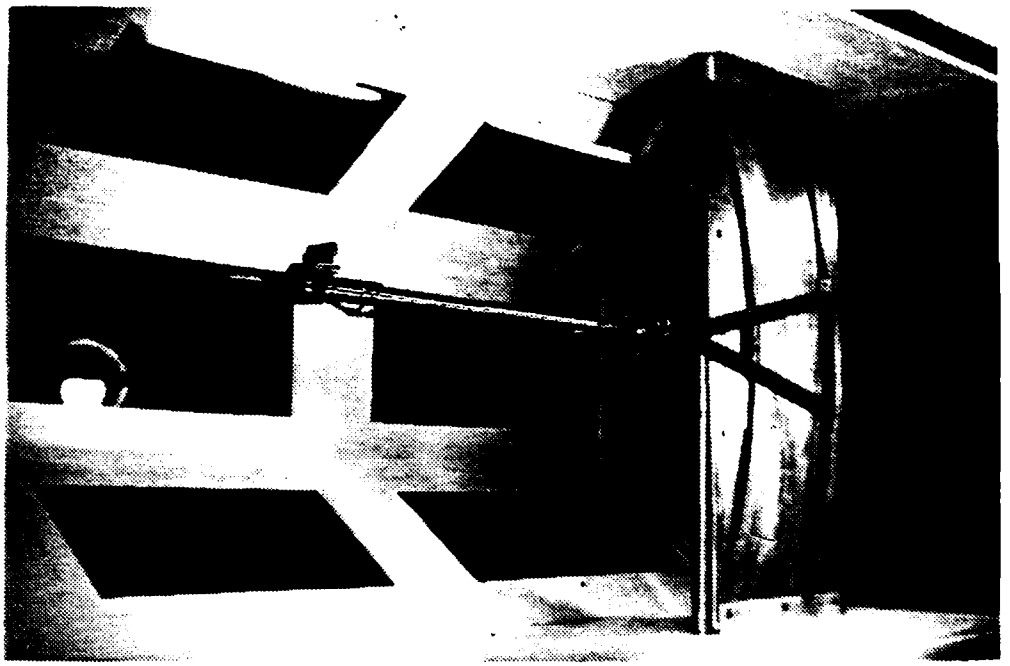


Figure 2.13 Sting Support Mounted in Test Section

C. BALANCE DESIGN

1. *Concept*

Initially a balance was desired that would measure all forces and moments that the model could experience. The difficulties in fabricating one with this capability, on the other hand, were numerous and would have required more time than was available. The design for a three-component balance was taken from one designed for use with small caliber projectiles, but modified, in that a 25 pound model had to be supported [Ref. 2: pp. 412-414]. This design gave lift, drag, and pitching moment, of which only the normal and axial(for lift and drag) channels were used. Figure 2.15 depicts the design of the balance as well as how each component works. The normal and axial components consist of elastic parallelograms that distort slightly, producing localized tension and compression in the webs.

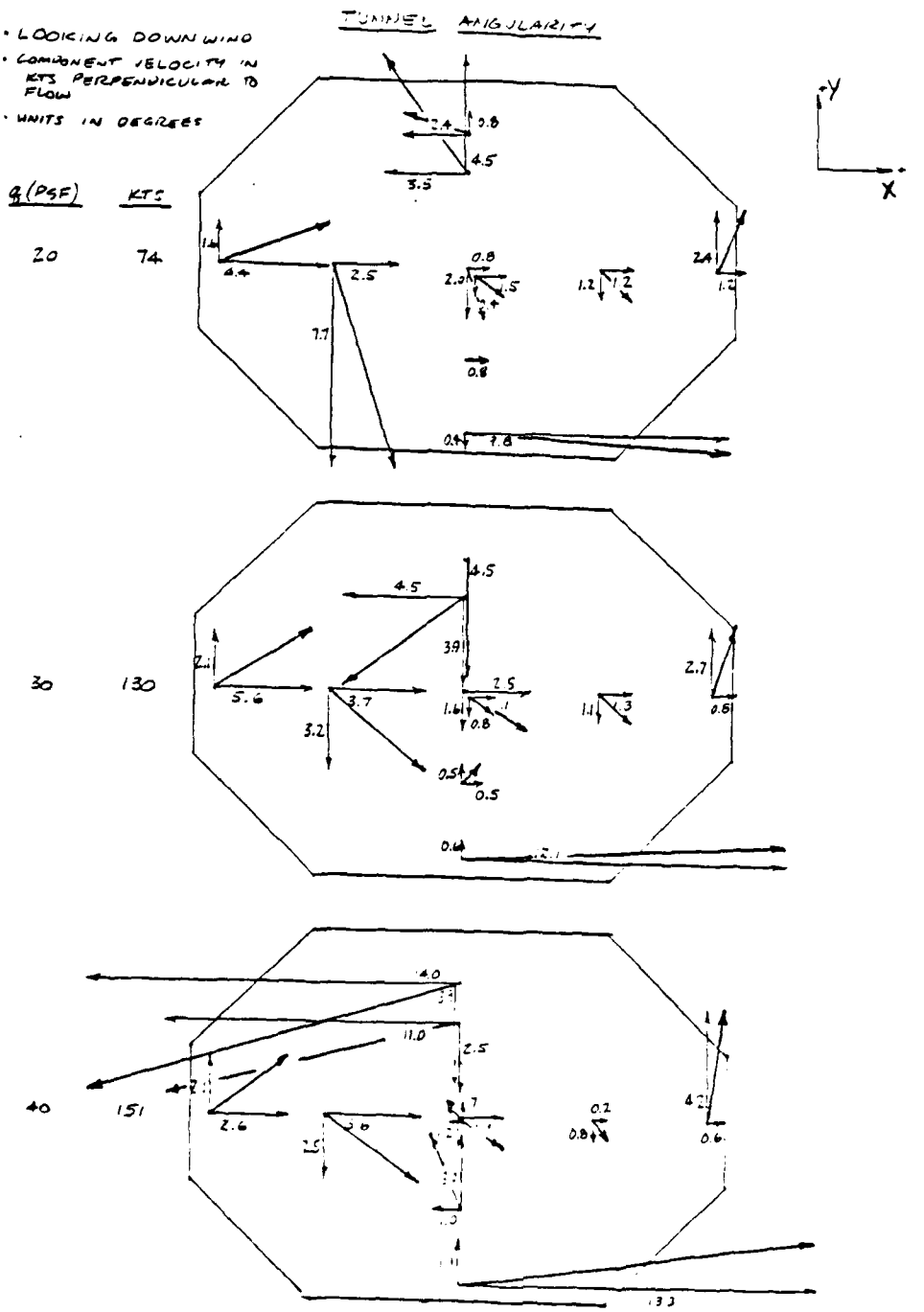


Figure 2.14 Flow Angularity at Model Location

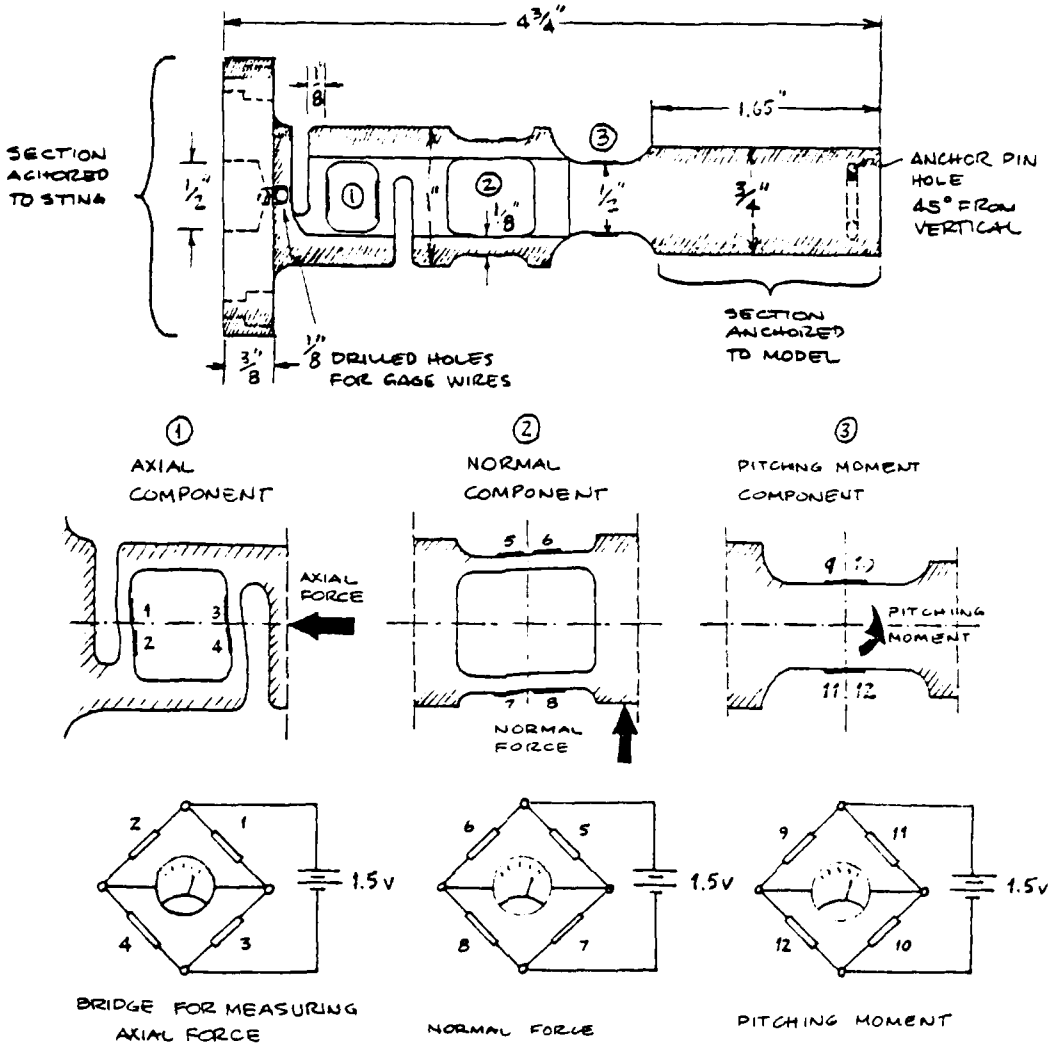


Figure 2.15 Balance Design with Component Description

Strain gages applied to these locations measured the elastic deformation that resulted, and hence the amount of force applied [Ref. 4: pp. 364-370]. The pitching moment component was of cantilever design with a positive pitching moment producing compression in the top surface and tension in the bottom.

Each component had four gages wired into a Wheatstone bridge which could be balanced (zeroed) once the weight of each model was applied [Ref. 4: pp. 110-111].

2. *Calibration*

The balance was calibrated to identify any interaction between normal and axial loading. A calibration rig consisted of the common fuselage and balance mounted on the sting at zero angle of attack(AOA). Using pinned fittings shown in Figure 2.18, the axial and normal components could be loaded independently. The wheatstone bridge for each component was balanced (zeroed) once the rig was in place. Weights from 0-20 pounds were placed on the pans, one pound at a time, producing a 20x20 matrix of 'raw' normal counts and one of axial counts (Figure A.8). Some interaction was present, as seen in Figure 2.16, where the degree of error can be seen as peaks (above expected readings) and valleys (below). A flat surface would indicate no interaction. The interaction surfaces are somewhat deceiving in that small errors at low loading conditions produced relatively large errors (peaks and valleys). A computer program was used to correct the actual data collected for interaction error, reducing its effect considerably (Figure 2.17 depicts the flow chart used).

3. *Instrumentation*

Figure 2.19 depicts a block diagram of the instrumentation used. The signal from each channel was split, allowing a raw reading and a conditioned reading. It was found that the movement of the model produced enough noise to cause the raw reading to be unreadable during normal operation.

A low pass filter, shown conceptually in Figure 2.20, was used to eliminate all frequencies above .5 hertz [Ref. 4: pp. 129-130]. This value was determined experimentally by plucking the nose of the model to introduce noise and varying the low cutoff frequency. At .5 hertz enough of the higher frequency vibrations had been eliminated to cause the conditioned signal to be readable. Lowering the cutoff frequency any further increased the settling time of the readout to where it became excessive(greater than 10 seconds).

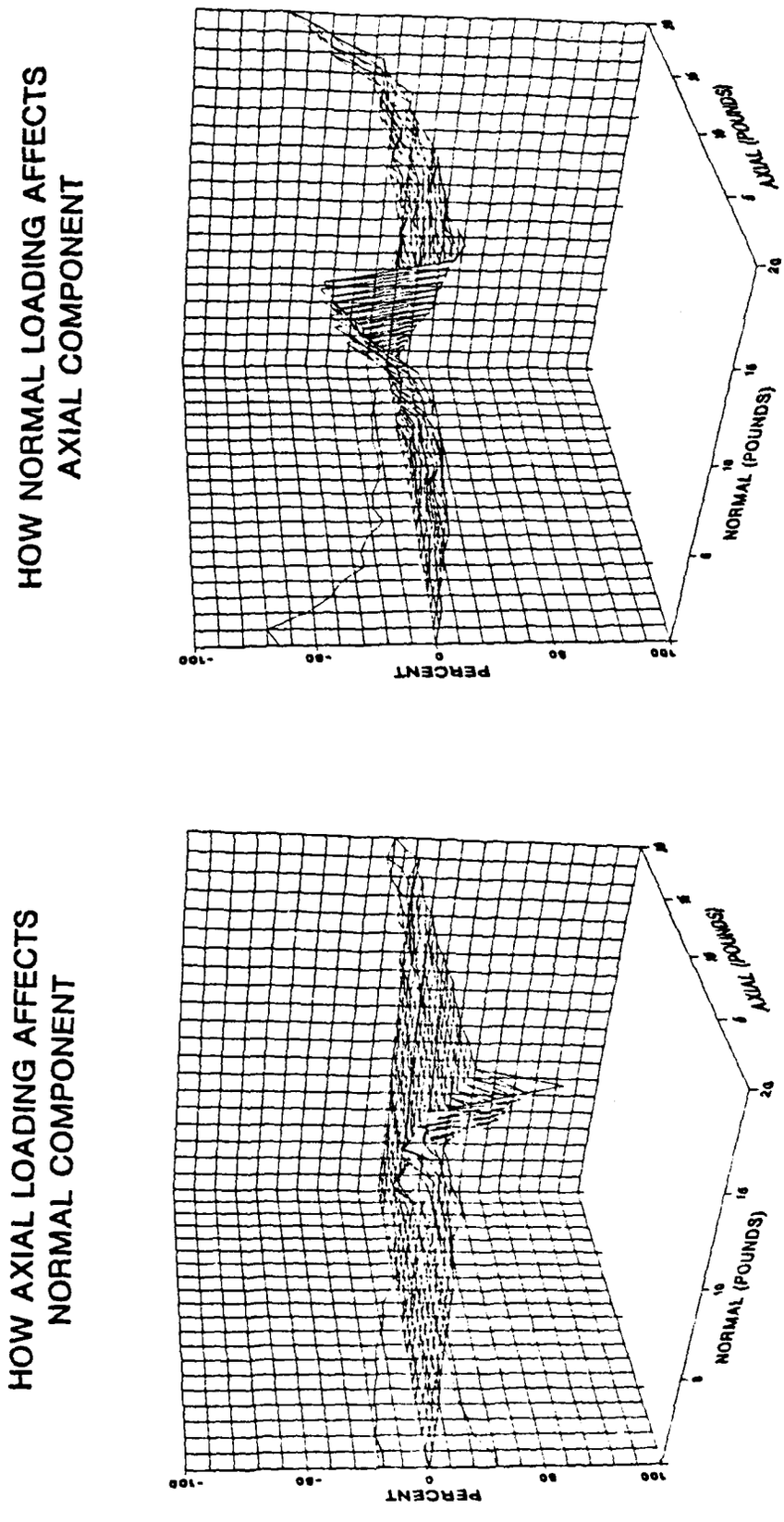


Figure 2.16 Visualization of Balance Interaction

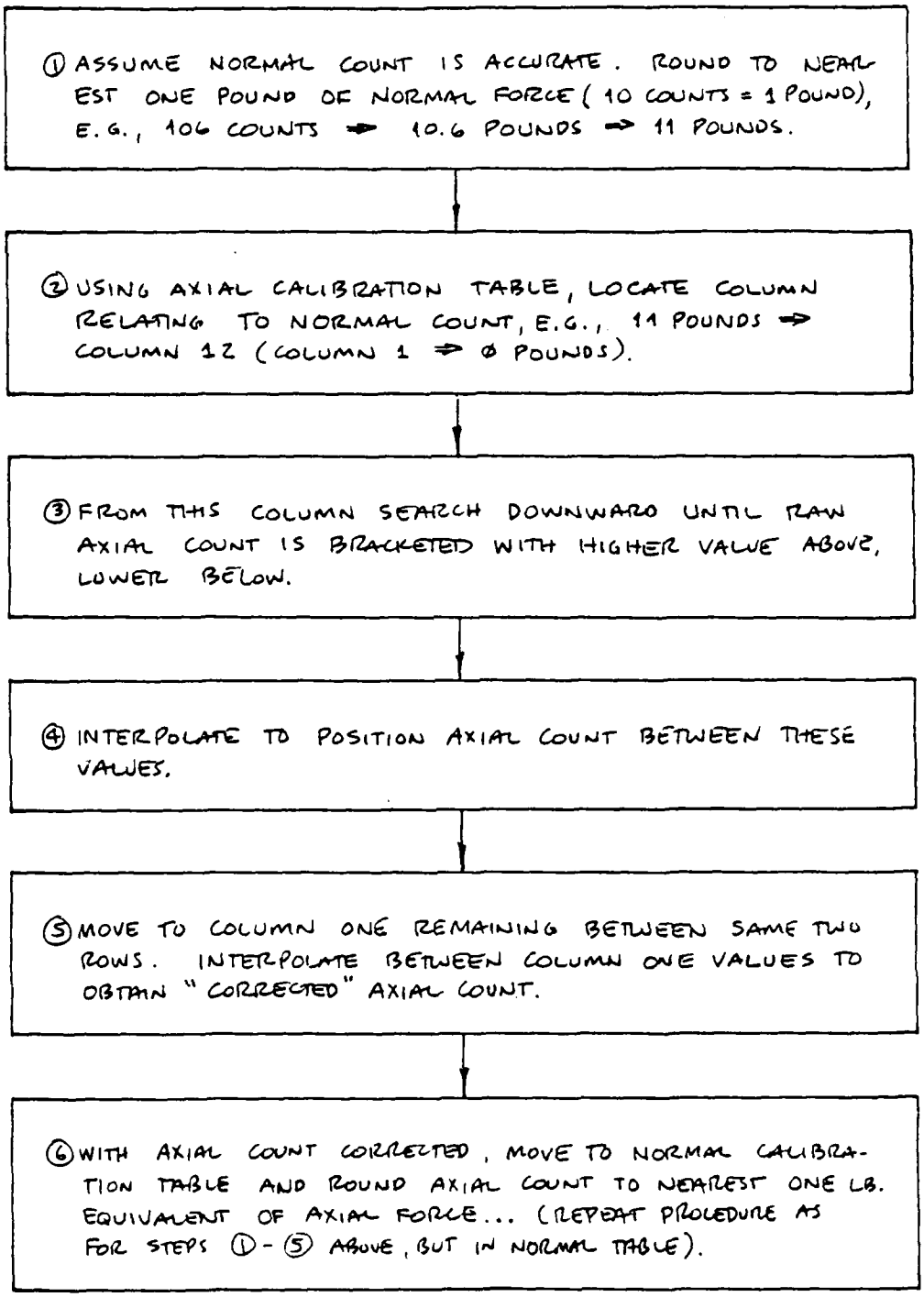


Figure 2.17 Flow Chart for Data Correction Due to Balance Interaction

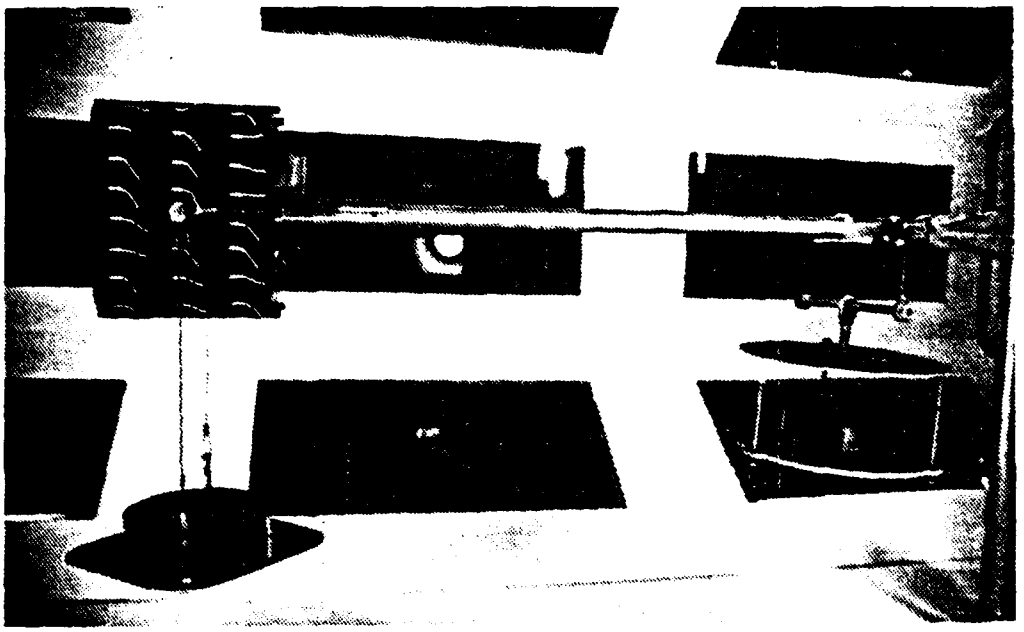


Figure 2.18 Calibration Rig for Axial and Normal Channels

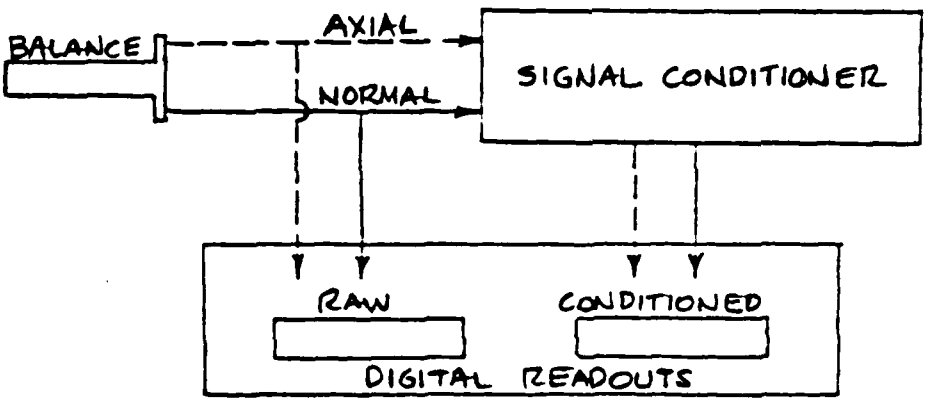


Figure 2.19 Electrical Instrumentation

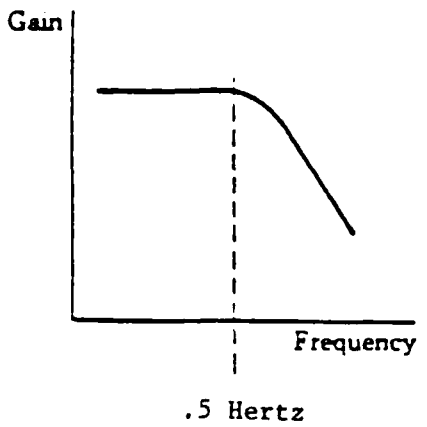


Figure 2.20 Principle of Low-Pass Filter

III. SOLUTION TO THE PROBLEM

A. DATA COLLECTION

To restrict the volume of information to be collected to a reasonable amount, the number of variables was limited. Four tunnel speeds were chosen for Q's of 10, 30, 50, and 70 psf, as were ten angles of attack, from +8 to -10 degrees, in 2 degree increments. Data was collected from digital readouts by hand, requiring 80 readings per model, a manageable number.

To standardize data collection a checklist was used prior to the testing of each model (Figure A.10). The balance and electrical equipment were calibrated before each data run (within 20 minutes) and afterwards with the zeroed readings drifting slightly if this time was exceeded. Figure A.8 contains a listing of the 9 data files, each reading taken in raw counts of normal and axial force (not corrected for balance interaction or the weight of the model).

B. DATA REDUCTION

Circuit boards used to provide an excitation voltage for each of the Wheatstone bridges (one per channel), and to amplify their output, were adequate, but only after many boards had been checked and discarded as faulty. The use of two digital voltmeters as displays, with one per channel, was good in that the decimal point could be varied to match the bridge outputs. The number of significant digits in the output was not initially known, but by varying the amplification for each channel, until noise prevented any further amplification, the decimal point was fixed and noisy digits were truncated. The number of significant digits that were readable (three) eventually became the number of digits in the 'counts' readout (where 10 pounds became 100 counts).

A FORTRAN program was written by Major Mair to convert the raw counts of normal and axial force to pounds of lift and drag(Figure A.9). From this the coefficients of lift and drag, and the equivalent flat plate area were calculated(Figure A.11). To determine these values, the raw counts were first corrected for balance interaction, then the weight of the model(as a function of AOA), was removed. The remaining counts were then converted to counts of lift and drag, used directly to solve for the required coefficients. To add a visual meaning to this data several parameters were plotted against one another.

C. GRAPHICAL ANALYSIS

Plotting all of the available parameters, for each of the given airspeeds, would produce too many curves. The following comparisons were made at Q's of 30 and 70 psf (Figures B.1-B.3).

1. Cd versus AOA
2. Cd versus Cl
3. Cd versus Cl squared

D. FLOW VISUALIZATION

The explanation of what causes lift and drag is not easily explained by numerical or a graphical interpretation. Instead, other techniques are required that augment the quantitative data, and in this situation tufting was used. 'Mini-tufting' the model was the desired method, but a strobe, possibly inadequate for the conditions of photography, prevented an extended trial an error development of the technique **[Ref. &mini]**. Instead, cotton tufting was used under floodlamp illumination to produce the desired results. Pictures were taken of sideviews of the model for AOA's of +8, 0, and -10 degrees for Q's of 30 and 70. This produced 54 pictures which were augmented with frontal and rear views as deemed necessary to explain the flow (Figures C.1-C.9). The film used was Tri-X by Kodak (ASA 400), pushed to 1200 and developed into contact prints. From these prints, the desired exposures were chosen and developed into useable full size prints and

halftones. The lens used were a 28-80mm macro-zoom for the side views and a Nikon 50mm for the front and rear views. The exposures were taken at 1/30th second and an F-stop of 5.6.

IV. RESULTS

A. QUANTITATIVE

The experimental hardware developed during the course of this thesis produced good results with some adjustments required for further testing. The physical arrangement of the sting support system, balance, and models all worked well and were relatively easy to work with. The support was sufficiently stiff enough to maintain model attitude under all wind tunnel conditions, and the balance, initially considered marginal in strength, was elastic enough to produce good strain gage output without plastic deformation. The electrical instrumentation was adequate in that only two channels, axial and normal required signal conditioning. Had more channels been necessary, conditioning would have been a problem, as a two channel conditioner was the only one available.

The air temperature rose significantly during the course of a test run which affected the axial reading, although temperature compensation had been designed into each component. With one of the wind tunnel drive fans missing, the turbulence level was higher than desired and this raised the air temperature as much as 10 degrees in a 10 minute run at a Q of 70 psf. This rise was not as significant for the lower Q's, with a rise of 2 or 3 degrees for the same amount of time. Data collection was limited to runs of 10 minutes or less for a Q of 70 psf.

Blockage was not considered a factor requiring correction for two reasons. Initially, the total blocking factor was estimated to be 0.00833, a product of the model frontal area (64 sq. in.) divided by tunnel cross-sectional area (1920 sq. in.) times 1/4 [Ref. 5: p. 9-4]. As each model was similar in cross-section and differed only slightly for the small AOA's considered, it was felt a correction was not necessary. Also an initial test of the change in airspeed due to a change in AOA from 0 to +8 degrees, e.g., was found to be very small, on the order of 3%.

This was measured with a Pitot tube mounted at the cross-sectional location of the model, 6 inches from the tunnel wall.

The output of the balance was considered to be unacceptable in that the drag should have been relatively high for +8 and -10 degrees and low for AOA's near zero. This was not the case, which was attributed to the asymmetrical design of the axial component which produced an unpredictable output. At any AOA other than zero degrees, the balance is influenced by nonlinear strains that produce nonlinear readings. The typical 'bucket', found on graphs of Cd versus AOA was not present (Figure B.1) indicating incorrect results.

B. QUALITATIVE

The flow visualization technique of cotton tufting was adequate to distinguish a difference in flows between various model combinations, but not between different Q's (30 and 70) for a particular model. This can be attributed to the insensitivity of the relatively heavy tufting material and the tape used to secure it. The boundary layer was influenced enough by the material to produce a turbulent boundary layer farther towards the nose than would have otherwise occurred. This influence was strong enough to eliminate the subtle differences that would have been present for the narrow band of Reynolds numbers that were tested. For a given model there was no difference distinguishing the tufted photographs for two different airspeeds,as one would expect. For this reason only one set of photographs, covering both Q's was included(Figures C.1-C.9).

The concept of Mini-tufting was tested to determine whether or not the existing strobe was powerful enough to illuminate the model. Figure A.12 depicts the layout used to photograph a Mini-tufted airfoil, mounted in place of the model and also gives a listing of the filters used [Ref. 6: p. 16]. The strobe, a General Radio electronic stroboscope, type 1540-P3, was only capable of 10 Joule bursts where 500 joules were required. It was felt that the higher flash rates this strobe is capable of would provide enough light over the 1/30th second

exposure needed to 'freeze' the tufts. A roll of Tri-X film was pushed to 1200 ASA and exposed at F3.5 from 1/60th second to 10 seconds. This was also done for F5.6 with the outcome expected to be a bracketing of the correct amount of light. The resulting photographs are not included as none showed anything more than slight shadows of the photographed airfoil.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The experimental apparatus designed and built to support this thesis was adequate to recommend further research. The pitching moment and normal component of the balance produced reliable output, especially the normal component. The axial component, on the other hand, was not sufficiently accurate and requires redesigning. A possible design to produce linear strain in the axial component is included in Figure 5.1

The tufting used was useful for visualizing the flow for a given model, but must be improved for comparing different models. The 'Mini-tufting' technique would be excellent in that it is non-intrusive and sensitive to small flow differences.

The graphical output was not accurate as a result of the balance data being erroneous. The axial component proved to be consistent but inaccurate and, as lift and drag readings are dependent upon this, the graphs are not helpful.

The flow visualization was adequate for indicating trends between model types, but determining nuances in the flow was found to be very difficult. Analyzing photos of a particular model for a given AOA, at different Q's resulted in no visible differences in the flow.

B. RECOMMENDATIONS

The following are given as recommendations to improve the accuracy of data and to decrease the time spent collecting data. Recommendations are listed in order of importance with the most important being first.

1. *Design/construct new balance.* The original design was found to be acceptable with respect to the normal and pitching moment channel but not the axial, due to the asymmetrical

design of that component. This resulted from the diameter of the balance at the axial location being too small. If this portion of the balance was thickened, a symmetric component could be designed. Figure 5.1 contains a possible design for such a balance with the inclusion of a yawing moment channel. This design allows for minimum remachining of the common fuselage. The strain gages applied to the present balance were for aluminum, but this was considered adequate for this application after having consulted with the strain gage manufacturer. The correct gages, for stainless steel, arrived too late for use, but could be used for a new design and would only improve the accuracy.

2. *Vibration damping system.* The movement of the model in the tunnel was sufficient enough to cause a requirement for signal conditioning. This movement was most likely a result of the stiffness of the sting support in the pitching and yawing planes, and possibly a result of the turbulence present in the test section. A system to damp this vibration would perhaps delete the requirement for signal conditioning. Figures 5.2 and 5.3 contain possible designs for such a vibration damping mechanism.
3. *Strobe for Mini-tufting.* An effort was made to use an existing low-powered electronic strobe to illuminate the models for photographing with Mini-tufts. The strobe was inadequate, but one powerful enough is available and would be a great improvement over the technique of flow visualization that was used. Reference &tufts describes the correct strobe, use of equipment, and gives ordering information.
4. *Thrust bearings for drive gear.* At times the current required to drive the sting was excessive requiring a change in the testing procedure to prevent the motor from overheating. The fact that thrust washers were used in the drive mechanism, instead of thrust bearings, is a likely cause of the increase in friction that resulted. Remachining the drive gear and

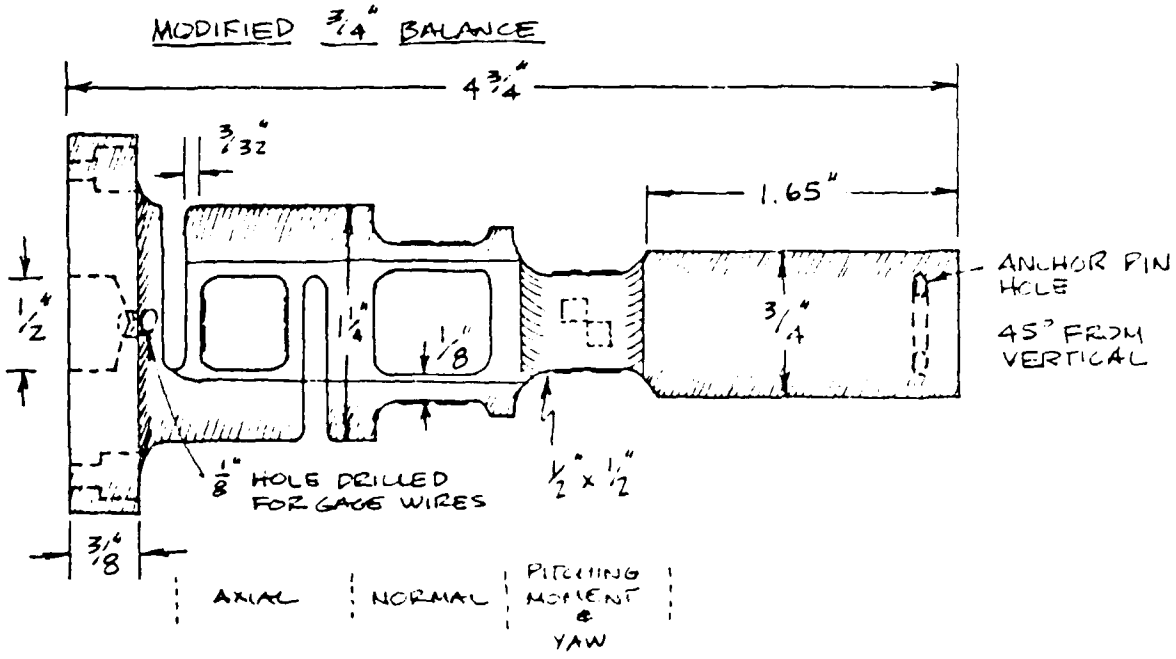


Figure 5.1 Proposed 4-Channel Balance Design

installing thrust bearings would extend the life of the drive mechanism and allow for a more powerful motor to be installed.

5. *Drive rod replacement.* To ensure that the sting support was available for early use, the drive rod used was a common threaded rod and not one with ACME threads. An ACME thread, where 90 degree thread faces, not angled faces are present, reduces the amount of friction as well as the torque

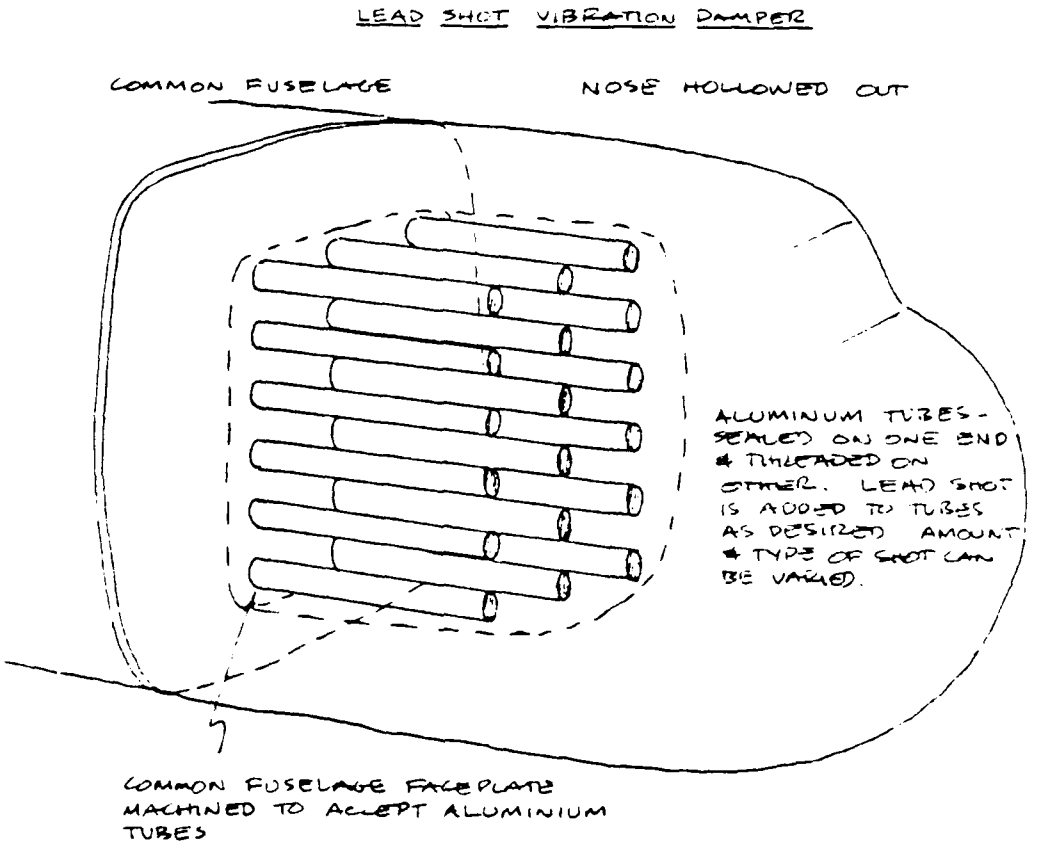


Figure 5.2 Vibration Damping System, 1st Design

required to drive the rod. The drive rod should be replaced to lower friction in the drive train.

6. *Drive motor*. The AOA drive motor was found to be too weak to drive the sting for prolonged periods without overheating. A capacitive start, 1/3 horsepower, reversing motor would increase the rate of AOA change, reducing the amount of time lost between data points and ensuring a longer life for the drive system.
7. *AOA limit switches*. No provisions were made to prevent the drive mechanism from jamming the sting support in the full up or full down position. This in fact did occur, but fortunately

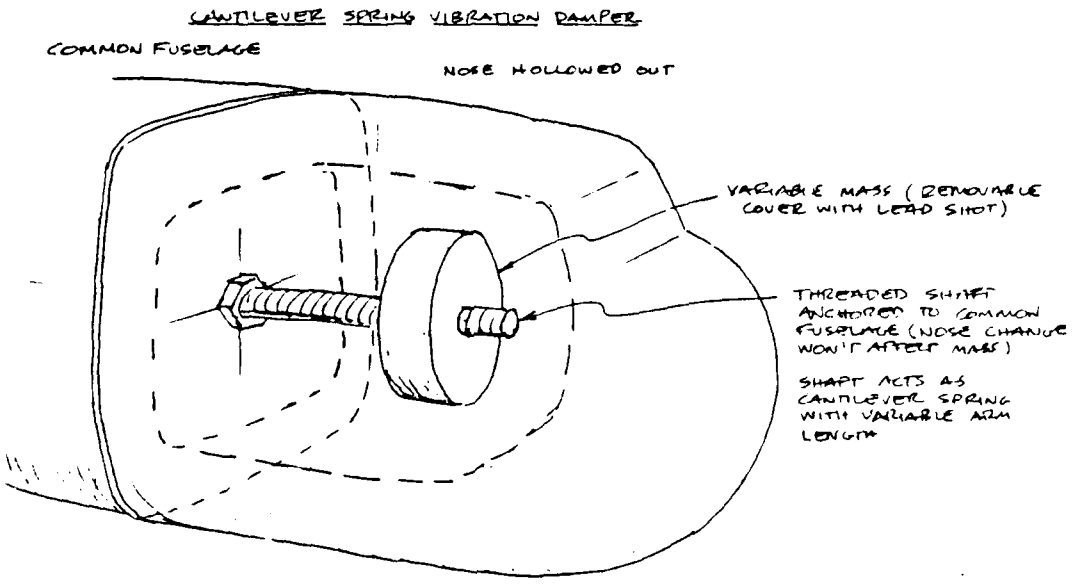


Figure 5.3 Vibration Damping System, 2nd Design

no damage was done. To prevent permanent damage limit switches in the form of DC relays could be installed on the sting support at the limit of travel.

8. *Signal conditioning*. Signal conditioning proved helpful for the axial and normal channels and would most likely help for any additional channels used in the future. The AOA readout was readable without any conditioning, but it would have helped. The fact that only a two channel conditioner was available prevented any other channels from being conditioned.
9. *Pitching moment strain gages*. The strain gages for the pitching moment component were mounted to provide for

temperature compensation, but in an inefficient way. If the two gages perpendicular to the longitudinal axis of the model were reapplied parallel to this axis, the output would double and temperature compensation would still be present.

10. *Axial component strain gages*. The readout of the axial component tended to drift during initial use of the balance. This was diagnosed as a gage that had peeled slightly, causing a change in the balancing of the Wheatstone bridge prior to use. Fortunately this condition was not present during testing, a result of the peeling having stopped. To ensure consistency in the axial component, the axial gages should be replaced.
11. *Computer program*. Many FORTRAN computer programs were written and modified to produce the graphical output used in this thesis. A more efficient approach would consolidate these programs into one that would contain the graphics programs as subroutines, requiring simple prompting prior to each run to produce the desired output.
12. *Wind tunnel survey*. The wind tunnel used is known to have poor test section conditions, mainly a result of the removal of one set of drive props and a shortened diffuser section which causes flow separation. But other problems exist as well and a complete tunnel survey would enable cost effective repair when funds become available. A survey would measure turbulence, velocity, and angularity in the test section at a range of tunnel speeds.
13. Those following this thesis should examine the effects of tunnel wall corrections and incorporate these into the computer program.

APPENDIX A
TABLES, FIGURES, AND PROGRAMS

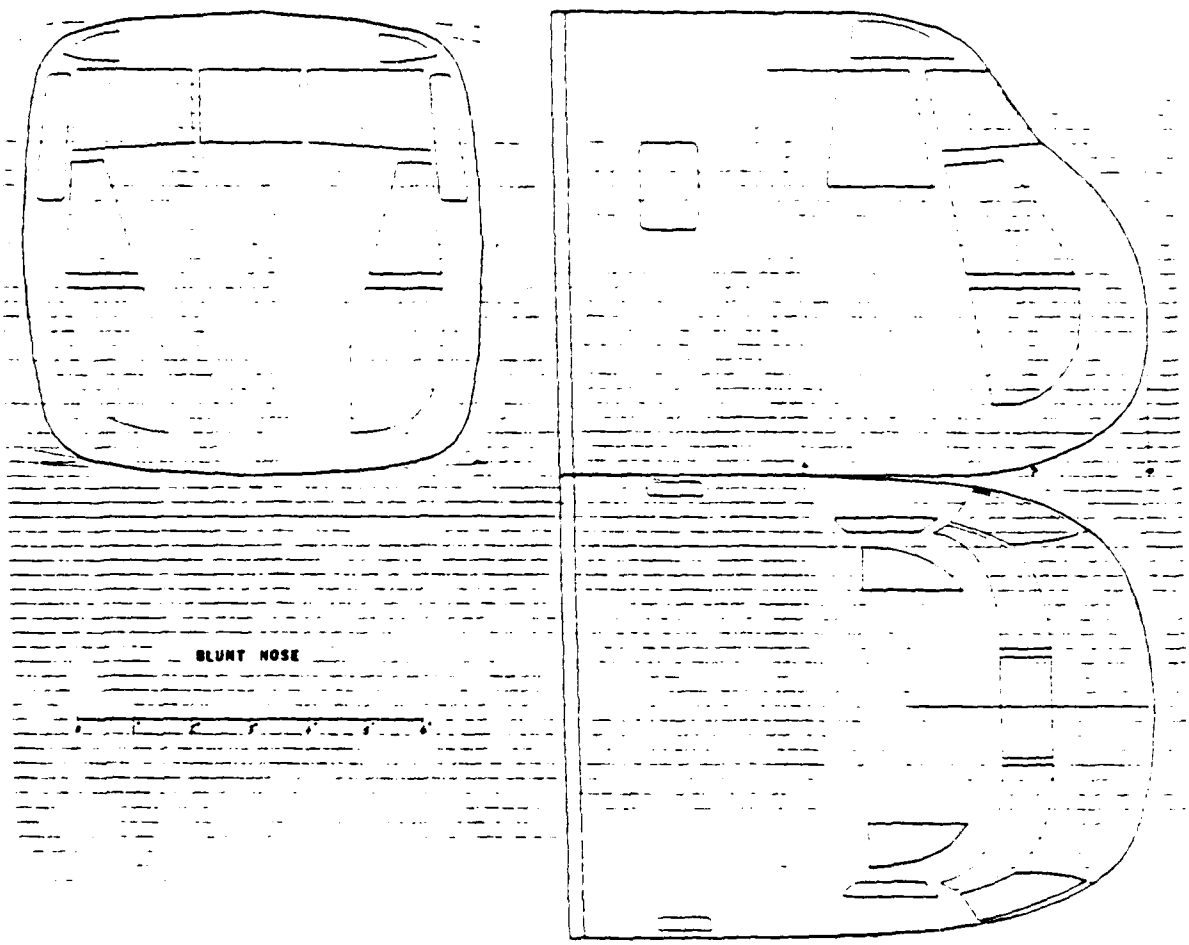


Figure A.1 Planview of Blunt Nose

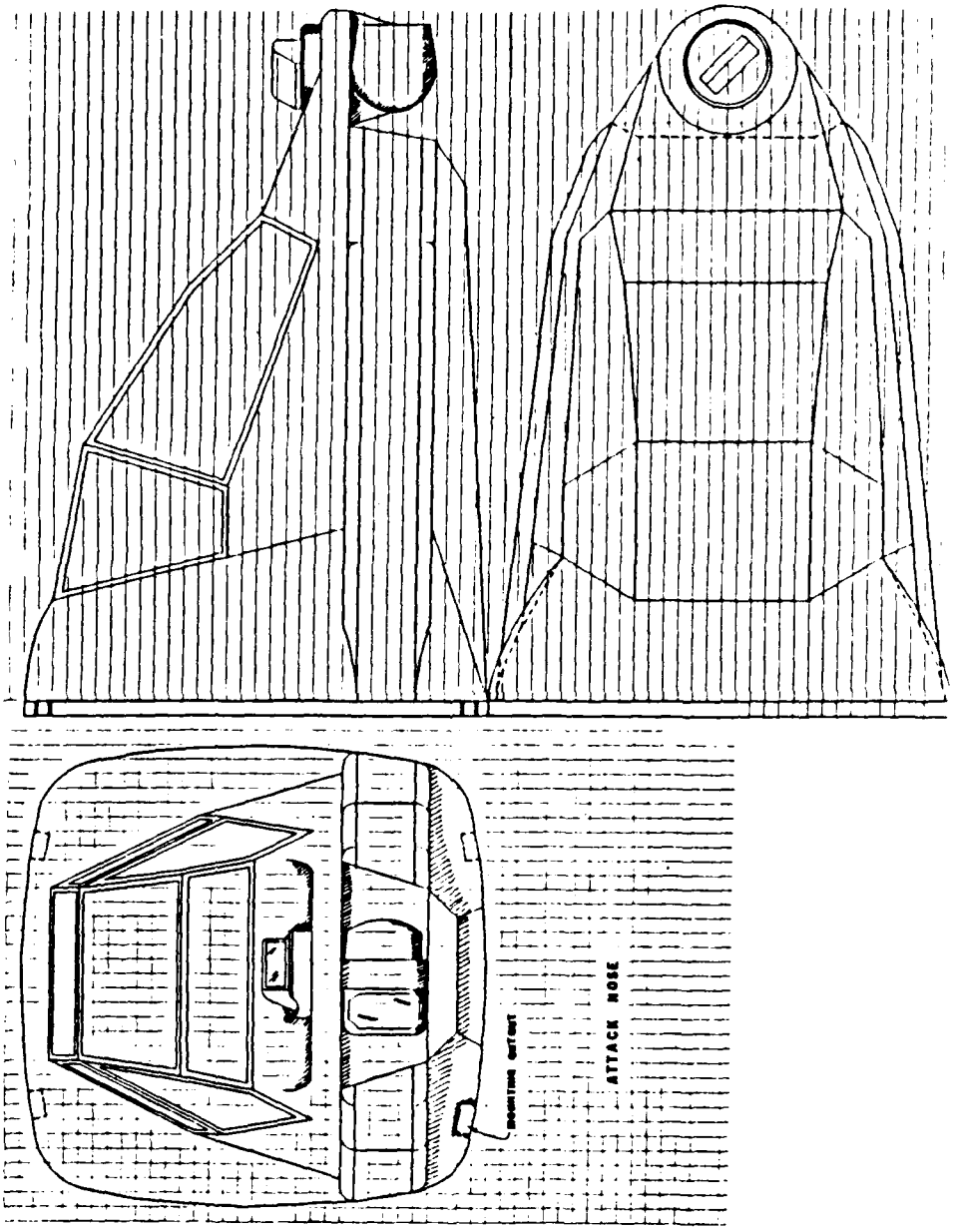


Figure A.2 Planview of Attack Nose

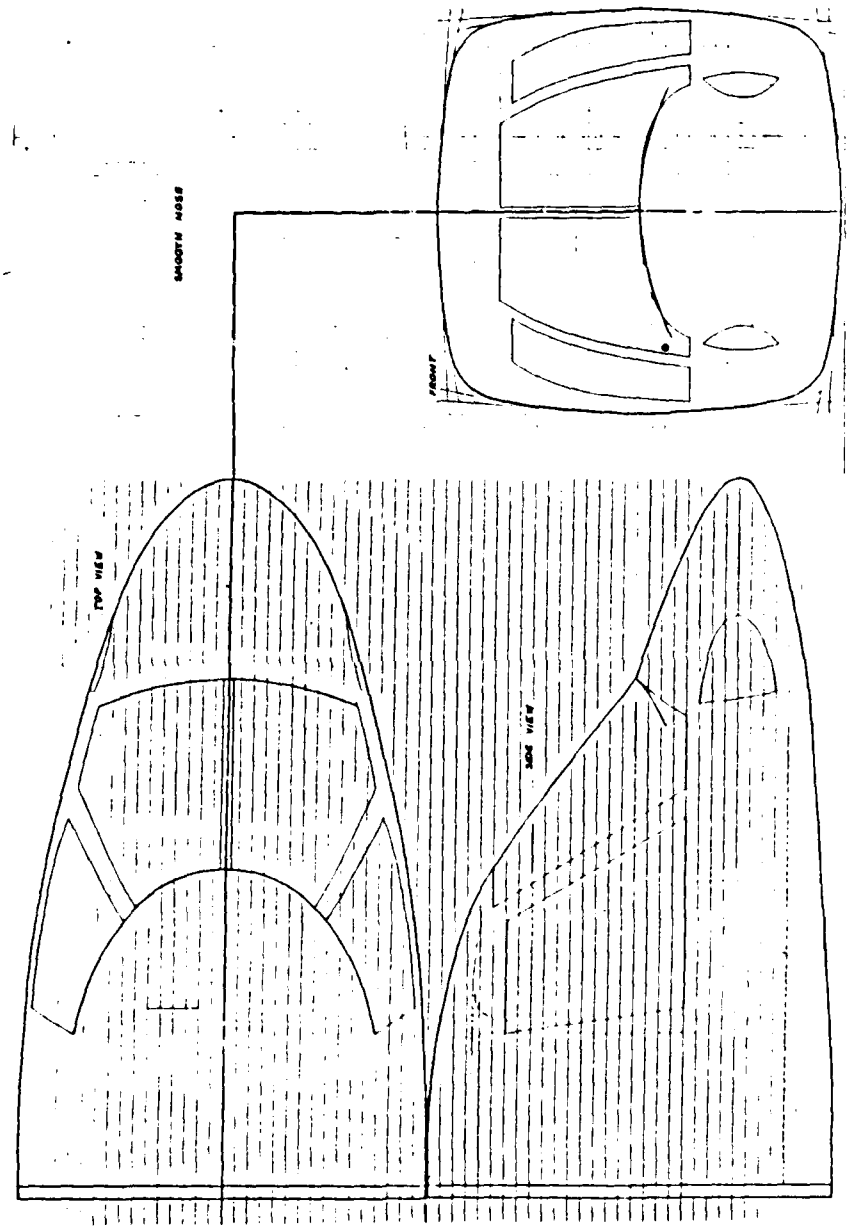


Figure A.3 Planview of Smooth Nose

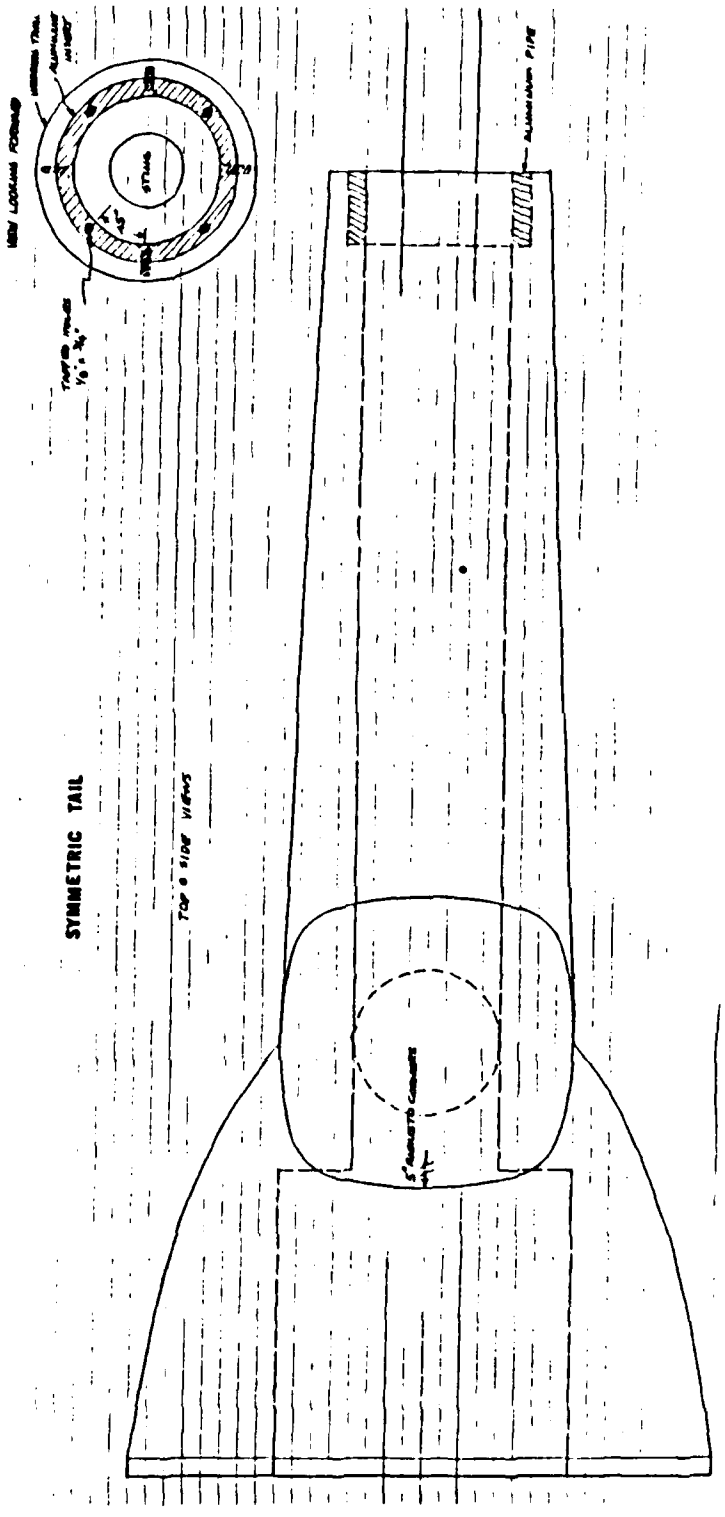


Figure A.4 Planview of Symmetric Tail

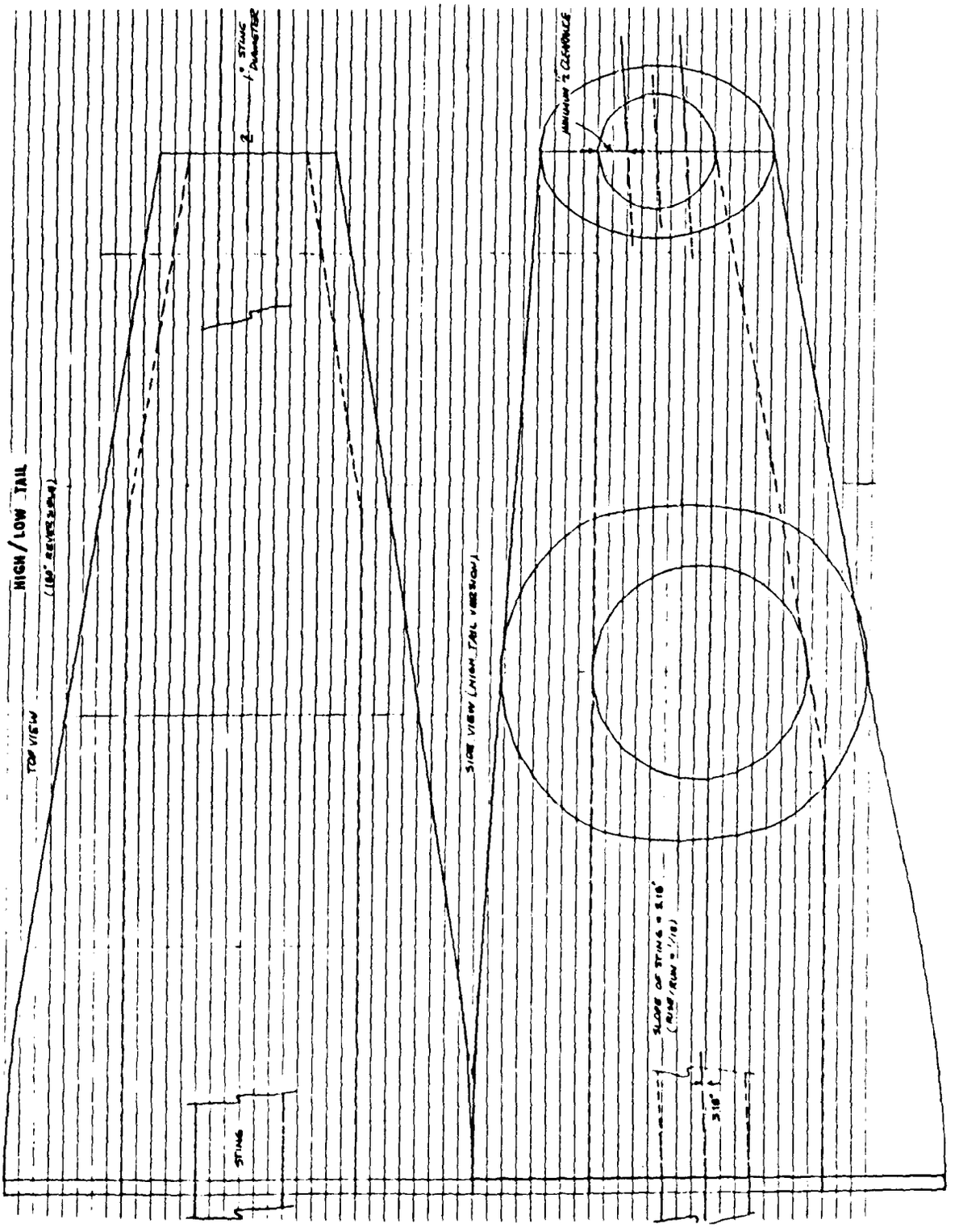


Figure A.5 Planview of High/Low Tail

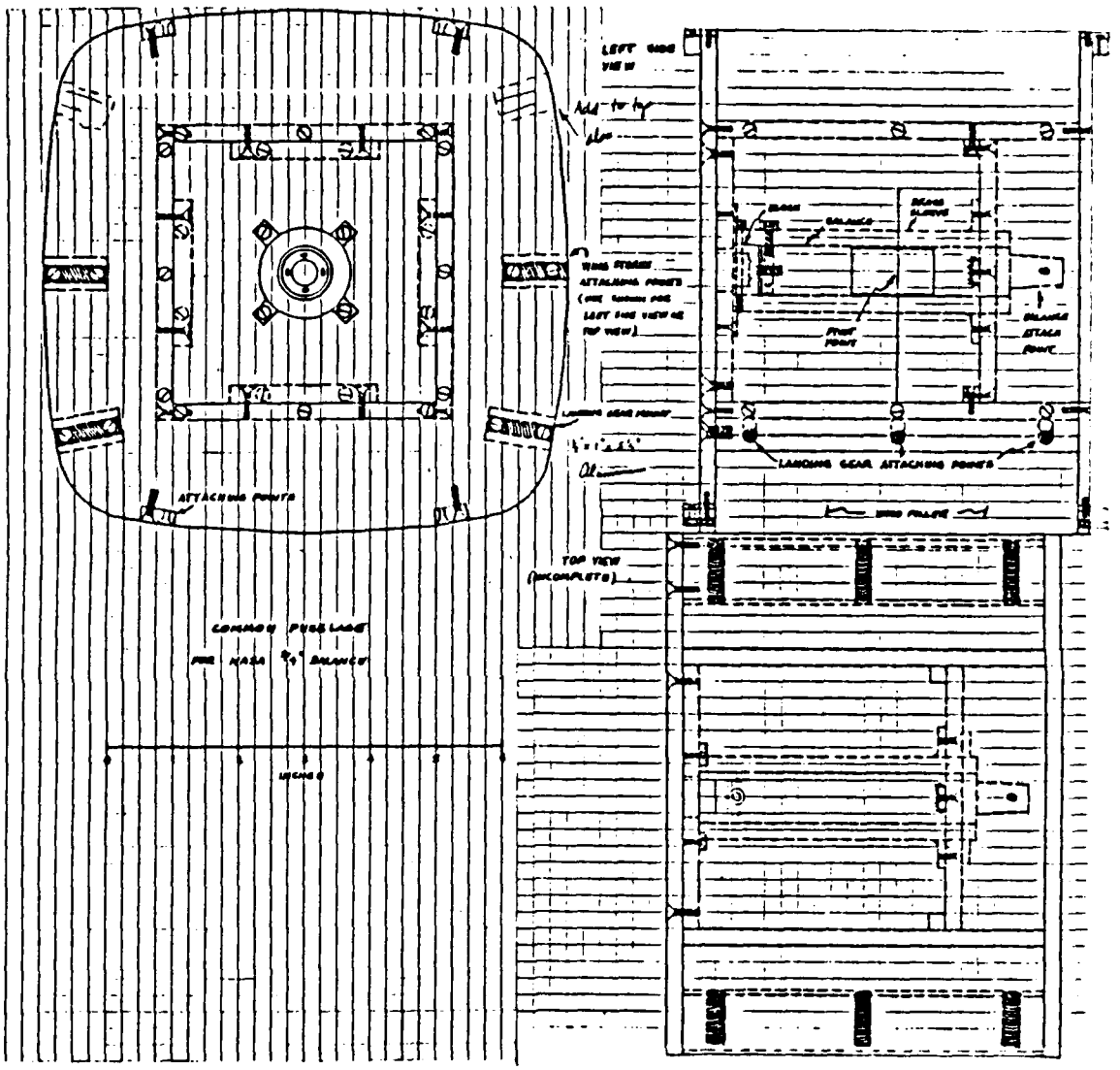


Figure A.6 Planview of Common Fuselage

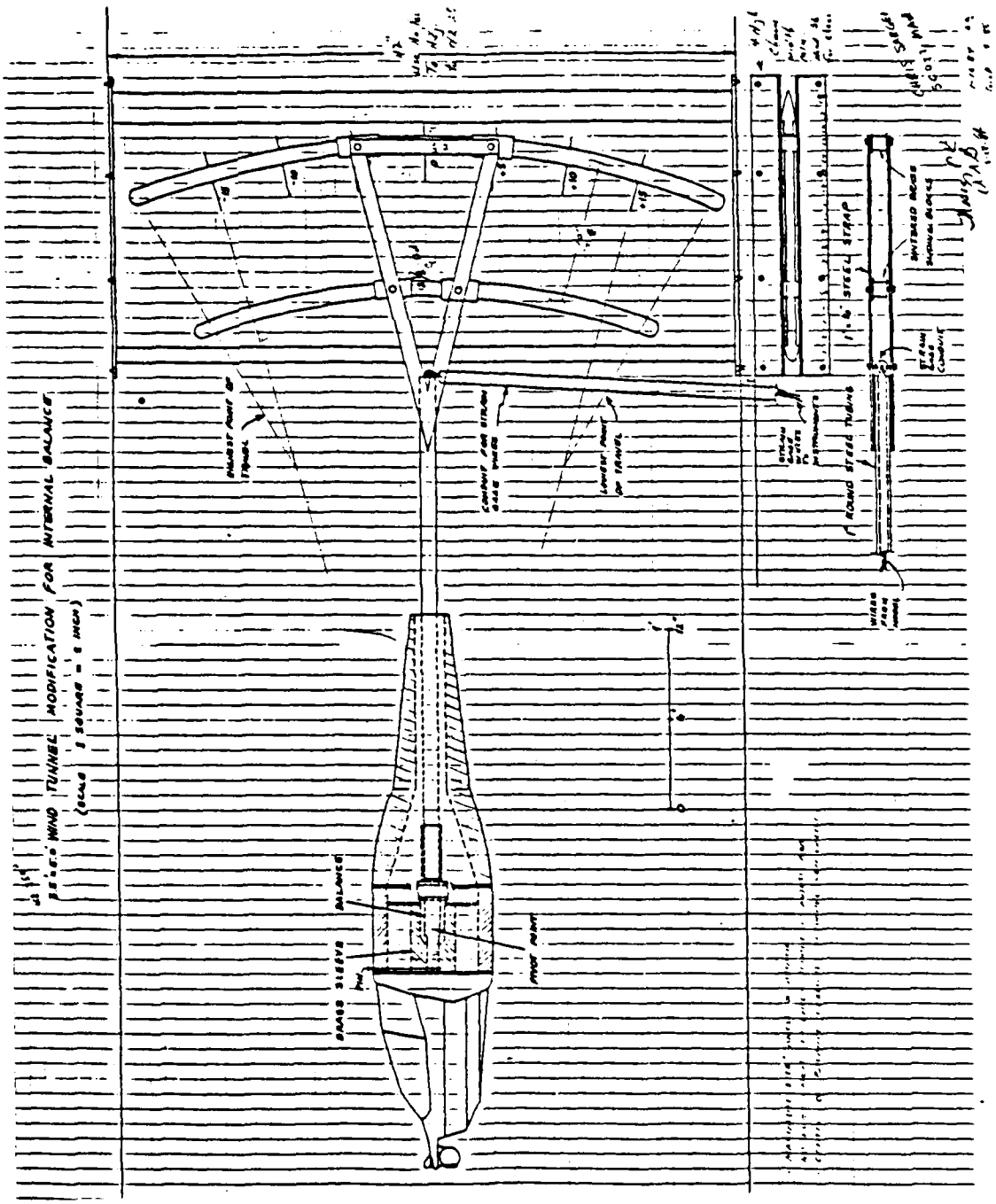


Figure A.7 Planview of Sting Support System

```
MOSR/TAIL=1/     REMARKS: RUN#1  ATTACK / HIGH
NORMAL    AXIAL
 100/      100/    (CORRECTION FACTOR)
   0/        0/    (AFTER-RUN ZERO READING)
----------Q=10----------
 AOA      NORMAL        AXIAL
   8/         6/          33/
   6/         3/          23/
   4/        -1/          20/
   2/        -3/           8/
   0/        -5/           2/
  -2/        -8/          -3/
  -4/        -9/         -12/
  -6/       -10/         -22/
  -8/       -12/         -30/
 -10/       -14/         -45/
----------Q=30----------
 AOA      NORMAL        AXIAL
   8/        20/          60/
   6/        12/          53/
   4/         5/          42/
   2/        -1/          33/
   0/       -10/          20/
  -2/       -18/          10/
  -4/       -25/           3/
  -6/       -32/         -10/
  -8/       -41/         -21/
 -10/       -50/         -35/
----------Q=50----------
 AOA      NORMAL        AXIAL
   8/        34/          80/
   6/        17/          80/
   4/         5/          74/
   2/        -5/          62/
   0/       -19/          53/
  -2/       -30/          45/
  -4/       -43/          35/
  -6/       -57/          23/
  -8/       -72/          10/
 -10/       -83/          -3/
----------Q=70----------
 AOA      NORMAL        AXIAL
   8/        53/          98/
   6/        31/          90/
   4/        11/          71/
   2/        -7/          56/
   0/       -28/          40/
  -2/       -43/          25/
  -4/       -60/          10/
  -6/       -82/          -4/
  -8/      -104/         -30/
 -10/      -127/         -45/
```

Figure A.8 Raw Data Files

NOSE/TAIL=2/ REMARKS: RUN#1_ATTACK/MIDDLE

NORMAL	AXIAL	
100/	100/	(CORRECTION FACTOR)
0/	0/	(AFTER-RUN OFF-ZERO READING)

0=10

AOA	NORMAL	AXIAL
8/	0/	41/
6/	0/	29/
4/	0/	23/
2/	-1/	14/
0/	-3/	6/
-2/	-4/	0/
-4/	-5/	-7/
-6/	-8/	-19/
-8/	-9/	-26/
-10/	-12/	-34/

0=30

AOA	NORMAL	AXIAL
8/	21/	55/
6/	11/	49/
4/	6/	40/
2/	0/	30/
0/	-8/	20/
-2/	-14/	13/
-4/	-20/	6/
-6/	-26/	-5/
-8/	-35/	-12/
-10/	-48/	-29/

0=50

AOA	NORMAL	AXIAL
8/	34/	78/
6/	21/	73/
4/	8/	63/
2/	0/	55/
0/	-12/	49/
-2/	-21/	43/
-4/	-33/	35/
-6/	-46/	29/
-8/	-60/	12/
-10/	-77/	0/

0=70

AOA	NORMAL	AXIAL
8/	50/	99/
6/	30/	90/
4/	15/	70/
2/	1/	54/
0/	-16/	45/
-2/	-31/	25/
-4/	-46/	15/
-6/	-65/	6/
-8/	-92/	-16/
-10/	-115/	-37/

Figure A.8 Raw Data Files(cont'd)

NOSE/TAIL=3/ REMARKS: RUN#1 ATTACK/LOW

NORMAL	AXIAL	
98/	98/	(CORRECTION FACTOR)
0/	0/	(AFTER-RUN OFF-ZERO READING)

0=10

AOA	NORMAL	AXIAL
8/	11/	42/
6/	7/	30/
4/	4/	22/
2/	0/	9/
0/	-2/	-3/
-2/	-4/	-7/
-4/	-6/	-15/
-6/	-7/	-27/
-8/	-9/	-38/
-10/	-11/	-48/

0=30

AOA	NORMAL	AXIAL
8/	30/	55/
6/	22/	48/
4/	13/	38/
2/	5/	27/
0/	-1/	14/
-2/	-8/	6/
-4/	-15/	2/
-6/	-21/	-13/
-8/	-32/	-28/
-10/	-38/	-40/

0=50

AOA	NORMAL	AXIAL
8/	50/	82/
6/	36/	73/
4/	20/	62/
2/	8/	46/
0/	-2/	36/
-2/	-14/	30/
-4/	-27/	20/
-6/	-39/	13/
-8/	-58/	-3/
-10/	-68/	-15/

0=70

AOA	NORMAL	AXIAL
8/	71/	99/
6/	51/	90/
4/	29/	75/
2/	10/	60/
0/	-8/	49/
-2/	-23/	27/
-4/	-45/	10/
-6/	-60/	-9/
-8/	-82/	-30/
-10/	-104/	-51/

Figure A.8 Raw Data Files(cont'd)

NOSE/TAIL=4/ REMARKS: RUN#1 BLUNT/HIGH

NORMAL	AXIAL	
100/	99/	(CORRECTION FACTOR)
0/	0/	(AFTER-RUN OFF-ZERO READING)

---------0=10---------

AOA	NORMAL	AXIAL
8/	8/	40/
6/	3/	29/
4/	0/	23/
2/	-2/	10/
0/	-4/	7/
-2/	-8/	-4/
-4/	-10/	-10/
-6/	-12/	-18/
-8/	-15/	-23/
-10/	-17/	-36/

---------0=30---------

AOA	NORMAL	AXIAL
8/	30/	55/
6/	20/	50/
4/	12/	40/
2/	4/	33/
0/	-1/	22/
-2/	-12/	14/
-4/	-19/	4/
-6/	-28/	-6/
-8/	-34/	-15/
-10/	-43/	-25/

---------0=50---------

AOA	NORMAL	AXIAL
8/	48/	80/
6/	32/	79/
4/	19/	70/
2/	6/	65/
0/	-5/	57/
-2/	-20/	41/
-4/	-32/	30/
-6/	-45/	22/
-8/	-59/	13/
-10/	-71/	0/

---------0=70---------

AOA	NORMAL	AXIAL
8/	65/	110/
6/	43/	100/
4/	22/	94/
2/	6/	73/
0/	-8/	62/
-2/	-30/	40/
-4/	-49/	23/
-6/	-68/	10/
-8/	-89/	0/
-10/	-108/	-15/

Figure A.8 Raw Data Files(cont'd)

```
NOSE/TAIL=5/     REMARKS: DUMAS_BLUNT/MIDDLE_____________
NORMAL     AXIAL
 100/       100/    (CORRECTION FACTOR)
   0/         0/    (AFTER-BIN OFF-ZERO BRADING)
----------Q=10----------
 AOA      NORMAL       AXIAL
   8/         8/         33/
   6/         4/         28/
   4/         1/         23/
   2/        -1/         13/
   0/        -2/          5/
  -2/        -4/         -3/
  -4/        -7/         -9/
  -6/        -8/        -22/
  -8/       -10/        -30/
 -10/       -11/        -37/
----------Q=30----------
 AOA      NORMAL       AXIAL
   8/        24/         60/
   6/        16/         48/
   4/         9/         40/
   2/         3/         30/
   0/        -3/         21/
  -2/       -10/         13/
  -4/       -17/          0/
  -6/       -25/        -10/
  -8/       -32/        -24/
 -10/       -40/        -34/
----------Q=50----------
 AOA      NORMAL       AXIAL
   8/        37/         83/
   6/        29/         79/
   4/        18/         67/
   2/         6/         58/
   0/        -2/         85/
  -2/       -15/         36/
  -4/       -23/         13/
  -6/       -40/          2/
  -8/       -53/         -5/
 -10/       -68/        -22/
----------Q=70----------
 AOA      NORMAL       AXIAL
   8/        63/        126/
   6/        44/        108/
   4/        27/         96/
   2/        10/         75/
   0/        -3/         62/
  -2/       -21/         40/
  -4/       -42/         20/
  -6/       -61/          3/
  -8/       -79/         -4/
 -10/      -101/        -22/
```

Figure A.8 Raw Data Files(cont'd)

NOSE/TAIL=6/ REMARKS: RUN#1 BLUNT/LOW

NORMAL	AXIAL	
100/	100/	(CORRECTION FACTOR)
0/	0/	(AFTER-RUN OFF-ZERO READING)

---0=10---

AOA	NORMAL	AXIAL
8/	11/	47/
6/	7/	40/
4/	4/	30/
2/	1/	22/
0/	-1/	15/
-2/	-3/	5/
-4/	-5/	0/
-6/	-7/	-5/
-8/	-9/	-13/
-10/	-9/	-25/

---0=30---

AOA	NORMAL	AXIAL
8/	36/	56/
6/	24/	48/
4/	17/	40/
2/	10/	30/
0/	2/	21/
-2/	-6/	12/
-4/	-13/	3/
-6/	-20/	-3/
-8/	-30/	-17/
-10/	-37/	-25/

---0=50---

AOA	NORMAL	AXIAL
8/	50/	85/
6/	42/	75/
4/	35/	65/
2/	20/	56/
0/	6/	47/
-2/	-3/	38/
-4/	-17/	30/
-6/	-30/	20/
-8/	-45/	3/
-10/	-53/	0/

---0=70---

AOA	NORMAL	AXIAL
8/	87/	94/
6/	69/	84/
4/	49/	70/
2/	29/	59/
0/	5/	40/
-2/	-12/	20/
-4/	-30/	3/
-6/	-50/	-10/
-8/	-69/	-23/
-10/	-93/	-45/

Figure A.8 Raw Data Files(cont'd)

NOSE/TAIL=7/ REMARKS: RUN#1_SMOOTH/HIGH

NORMAL	AXIAL	
100/	100/	(CORRECTION FACTOR)
0/	0/	(AMPLIFIER OFF-ZERO READING)

Q=10

AOA	NORMAL	AXIAL
8/	8/	40/
6/	4/	34/
4/	1/	26/
2/	-2/	20/
0/	-6/	7/
-2/	-9/	2/
-4/	-10/	-4/
-6/	-13/	-18/
-8/	-16/	-23/
-10/	-19/	-32/

Q=30

AOA	NORMAL	AXIAL
8/	15/	44/
6/	8/	33/
4/	1/	20/
2/	-2/	19/
0/	-8/	7/
-2/	-15/	-3/
-4/	-19/	-12/
-6/	-25/	-22/
-8/	-30/	-33/
-10/	-37/	-43/

Q=50

AOA	NORMAL	AXIAL
8/	42/	93/
6/	27/	78/
4/	13/	70/
2/	1/	63/
0/	-13/	45/
-2/	-26/	35/
-4/	-41/	17/
-6/	-56/	3/
-8/	-70/	-8/
-10/	-82/	-20/

Q=70

AOA	NORMAL	AXIAL
8/	65/	114/
6/	39/	90/
4/	20/	80/
2/	0/	58/
0/	-20/	45/
-2/	-39/	25/
-4/	-63/	5/
-6/	-84/	-12/
-8/	-105/	-29/
-10/	-128/	-37/

Figure A.8 Raw Data Files(cont'd)

```
NOSE/TAIL=0/     REMARKS: RUN#1_SMOOTH/MIDDLE_____________
NORMAL    AXIAL
 100/      100/    (CORRECTION FACTOR)
   0/        0/    (AFTER-RUN OFF-ZERO READING)
----------0=10----------
 AOA      NORMAL        AXIAL
   8/         6/          38/
   6/         4/          32/
   4/         0/          20/
   2/        -1/          12/
   0/        -5/           4/
  -2/        -6/          -2/
  -4/       -10/         -13/
  -6/       -10/         -28/
  -8/       -12/         -30/
 -10/       -13/         -40/
----------0=30----------
 AOA      NORMAL        AXIAL
   8/        27/          65/
   6/        19/          50/
   4/         9/          48/
   2/         3/          38/
   0/        -3/          24/
  -2/       -11/          15/
  -4/       -21/           2/
  -6/       -32/          -8/
  -8/       -30/         -18/
 -10/       -49/         -39/
----------0=50----------
 AOA      NORMAL        AXIAL
   8/        36/          87/
   6/        23/          78/
   4/        10/          67/
   2/        -2/          58/
   0/       -13/          42/
  -2/       -27/          33/
  -4/       -40/          17/
  -6/       -53/           3/
  -8/       -57/          -5/
 -10/       -83/         -22/
----------0=70----------
 AOA      NORMAL        AXIAL
   8/        55/         111/
   6/        39/          98/
   4/        19/          79/
   2/         1/          61/
   0/       -15/          42/
  -2/       -35/          25/
  -4/       -56/           3/
  -6/       -80/         -13/
  -8/      -102/         -28/
 -10/      -121/         -55/
```

Figure A.8 Raw Data Files(cont'd)

NOSE/TAIL=2/ REMARKS: RUN#1_SMOOTH/LOW

NORMAL	AXIAL	
98/	100/	(CORRECTION FACTOR)
0/	0/	(AFTER-RUN OFF-ZERO READING)

0=10

AOA	NORMAL	AXIAL
8/	12/	42/
6/	9/	29/
4/	5/	20/
2/	2/	7/
0/	0/	2/
-2/	-2/	-7/
-4/	-4/	-19/
-6/	-6/	-24/
-8/	-7/	-38/
-10/	-9/	-45/

0=30

AOA	NORMAL	AXIAL
8/	38/	60/
6/	29/	52/
4/	20/	40/
2/	10/	29/
0/	4/	18/
-2/	-2/	2/
-4/	-12/	-12/
-6/	-21/	-22/
-8/	-30/	-33/
-10/	-36/	-47/

0=50

AOA	NORMAL	AXIAL
8/	53/	83/
6/	44/	77/
4/	27/	53/
2/	14/	54/
0/	1/	32/
-2/	-13/	26/
-4/	-29/	19/
-6/	-43/	3/
-8/	-57/	-12/
-10/	-72/	-29/

0=70

AOA	NORMAL	AXIAL
8/	83/	109/
6/	62/	90/
4/	40/	80/
2/	19/	54/
0/	0/	35/
-2/	-21/	20/
-4/	-42/	0/
-6/	-64/	-21/
-8/	-88/	-42/
-10/	-105/	-65/

Figure A.8 Raw Data Files(cont'd)

TABLE 1

Balance Calibration Data, Normal Component

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	POUNDS OF NORMAL FORCE
200	201	201	200	201	200	200	201	200	200	200	200	200	200	199	199	200	198	198	199	200	20
191	191	191	191	191	190	191	191	190	190	190	190	190	190	189	189	189	188	189	189	190	19
180	181	181	180	181	180	181	181	180	180	180	181	180	180	178	178	179	178	178	178	179	18
170	171	171	171	171	170	171	170	170	170	170	170	170	170	168	168	169	168	167	168	168	17
160	161	161	161	161	160	161	160	160	160	159	160	160	160	158	158	159	158	157	158	158	16
150	151	151	150	151	151	151	150	150	150	149	150	150	150	149	149	148	149	147	148	149	15
140	140	141	140	141	140	140	140	141	140	139	140	140	140	138	138	139	139	138	139	139	14
130	130	131	130	130	130	130	130	130	130	130	130	130	130	128	128	129	127	127	128	128	13
120	120	121	120	120	120	120	120	121	120	120	120	120	120	118	118	119	117	117	118	118	12
110	110	110	110	110	110	110	110	110	110	110	110	109	110	108	108	109	107	107	108	107	11
100	100	100	100	100	100	100	100	100	100	100	100	99	100	97	96	98	97	97	96	98	10
92	91	91	90	90	90	90	90	90	90	90	89	88	90	89	87	87	87	88	87	88	9
81	81	81	80	80	80	80	79	79	80	80	78	78	80	78	77	76	76	77	77	78	8
71	70	70	70	70	69	70	69	70	70	69	69	68	70	68	68	67	67	67	67	68	7
61	60	60	60	59	60	60	59	60	60	59	59	58	60	57	57	57	57	58	56	58	6
50	50	50	50	50	50	50	49	50	50	49	49	49	50	47	48	46	47	48	46	48	5
40	41	41	40	40	40	40	40	39	40	39	39	39	39	37	37	36	37	39	36	37	4
30	31	30	30	30	30	30	29	28	30	29	29	29	29	28	27	27	26	28	26	27	3
20	21	20	20	20	19	19	18	18	20	19	18	18	18	16	17	17	16	18	17	17	2
10	10	10	10	10	10	10	9	9	9	9	7	7	8	7	7	7	6	8	6	7	1
0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	3	3	0
-10	-10	-10	-10	-10	-10	-10	-9	-9	-9	-9	-7	-7	-8	-7	-7	-7	-6	-8	-6	-7	-1
-20	-21	-20	-20	-20	-19	-19	-18	-18	-20	-19	-18	-18	-18	-16	-17	-17	-16	-18	-17	-17	-2
-30	-31	-30	-30	-30	-30	-30	-29	-28	-30	-29	-29	-29	-29	-28	-27	-27	-26	-28	-26	-27	-3
-40	-41	-41	-40	-40	-40	-40	-40	-39	-40	-39	-39	-39	-39	-37	-37	-36	-37	-39	-36	-37	-4
-50	-50	-50	-50	-50	-50	-50	-49	-50	-50	-49	-49	-49	-50	-47	-48	-46	-47	-48	-46	-48	-5
-61	-60	-60	-60	-59	-60	-60	-59	-60	-60	-59	-59	-58	-60	-57	-57	-57	-57	-58	-56	-58	-6
-71	-70	-70	-70	-70	-69	-70	-69	-70	-70	-69	-69	-68	-70	-68	-69	-67	-67	-67	-67	-68	-7
-81	-81	-81	-80	-80	-80	-80	-79	-79	-80	-80	-78	-78	-80	-78	-77	-76	-76	-77	-77	-78	-8
-92	-91	-91	-90	-90	-90	-90	-90	-90	-90	-90	-89	-88	-90	-88	-87	-87	-87	-88	-87	-88	-9
-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-99	-100	-97	-96	-98	-97	-97	-96	-98	-10
-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-109	-110	-108	-108	-109	-107	-107	-108	-107	-11
-120	-120	-121	-120	-120	-120	-120	-120	-121	-120	-120	-120	-120	-120	-118	-118	-119	-117	-117	-118	-119	-12
-130	-130	-131	-130	-130	-130	-130	-130	-130	-130	-130	-130	-130	-130	-128	-128	-129	-127	-127	-128	-128	-13
-140	-140	-141	-140	-141	-140	-140	-140	-141	-140	-139	-140	-140	-140	-138	-138	-139	-139	-139	-139	-139	-14
-150	-151	-151	-150	-151	-151	-151	-150	-150	-150	-149	-150	-150	-150	-148	-148	-148	-149	-147	-148	-149	-15
-160	-161	-161	-161	-161	-160	-161	-160	-160	-160	-159	-160	-160	-160	-158	-158	-159	-158	-157	-158	-158	-16
-170	-171	-171	-171	-171	-170	-171	-170	-170	-170	-170	-170	-170	-170	-168	-168	-169	-168	-167	-168	-168	-17
-180	-181	-181	-190	-181	-180	-181	-181	-180	-180	-180	-181	-180	-180	-178	-178	-179	-178	-178	-178	-179	-18
-191	-191	-191	-191	-191	-190	-191	-191	-190	-190	-190	-190	-190	-190	-189	-189	-189	-188	-190	-189	-190	-19
-200	-201	-201	-200	-201	-200	-200	-201	-200	-200	-200	-200	-200	-200	-199	-199	-200	-198	-198	-199	-200	-20

POUNDS OF AXIAL FORCE

THIS TABLE INDICATES THE 'NORMAL' READOUT, IN COUNTS, WHEN THE BALANCE WAS LOADED UNDER THE ABOVE CONDITIONS. THE NEGATIVE OUTPUT WAS MIRRORED TO PRODUCE A POSITIVE QUADRANT. THE MAPPING THAT RESULTED WAS USED TO CORRECT THE AXIAL DATA COLLECTED DURING TEST RUNS.

TABLE 2

Balance Calibration Data, Axial Component

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	POUNDS OF AXIAL FORCE
200	198	198	198	196	196	195	194	194	194	193	190	188	188	186	185	184	184	184	183	183	20
190	189	188	188	187	187	186	186	185	184	183	182	179	179	177	176	176	173	173	173	172	19
180	180	179	177	176	176	176	175	174	173	171	169	168	167	165	164	163	160	159	158	158	18
170	170	170	170	169	168	168	167	166	165	162	161	160	160	158	156	156	154	152	150	149	17
160	160	160	157	156	154	153	152	151	150	150	150	149	149	148	146	145	144	143	142	141	16
151	150	151	150	148	146	145	144	141	139	137	139	138	137	137	136	135	134	133	131	130	15
140	140	139	139	138	137	137	137	135	134	131	131	131	130	130	130	129	128	126	125	123	14
130	130	130	130	129	129	129	129	128	127	126	124	123	122	120	120	118	118	116	115	114	13
120	120	120	120	119	119	119	116	115	115	113	112	111	109	109	106	106	105	105	105	104	12
110	110	108	109	107	106	106	106	104	104	104	103	104	103	102	101	98	96	93	92	91	11
100	100	99	98	97	96	95	94	95	93	91	90	89	89	88	88	86	84	83	83	82	10
90	90	89	89	89	88	88	87	86	85	83	83	82	81	80	79	79	78	77	77	77	9
80	80	79	78	78	76	76	75	75	74	73	72	71	70	69	66	65	65	64	63	62	8
70	70	69	68	67	66	66	65	65	65	63	60	60	59	58	57	56	55	54	53	52	7
60	60	59	59	58	57	56	56	55	54	54	54	50	50	50	49	49	47	46	46	45	6
50	48	48	46	46	45	44	43	42	41	40	40	40	39	39	38	36	34	33	33	32	5
40	41	40	39	38	37	37	36	35	35	34	32	30	28	27	26	24	23	23	23	23	4
30	30	30	30	27	27	26	26	24	23	23	21	20	19	18	17	16	16	15	14	14	3
20	20	20	20	20	19	18	16	15	15	14	13	12	12	12	11	10	9	8	7	6	2
10	10	10	8	7	6	5	4	3	3	2	1	1	0	0	-1	-1	-2	-2	-2	-3	1
0	0	0	0	0	-1	-2	-3	-4	-4	-4	-4	-5	-7	-9	-9	-10	-12	-13	-13	-14	0
-10	-10	-10	-8	-7	-6	-5	-4	-3	-3	-2	-1	-1	0	0	1	1	2	2	2	3	-1
-20	-20	-20	-20	-20	-19	-18	-16	-15	-15	-14	-13	-12	-12	-12	-11	-10	-9	-8	-7	-6	-2
-30	-30	-30	-30	-27	-27	-26	-26	-24	-23	-23	-21	-20	-19	-18	-17	-16	-16	-15	-14	-14	-3
-40	-41	-40	-39	-38	-37	-37	-36	-35	-35	-34	-32	-30	-28	-27	-26	-24	-23	-23	-23	-23	-4
-50	-48	-48	-46	-46	-45	-44	-43	-42	-41	-40	-40	-40	-39	-39	-38	-36	-34	-33	-33	-32	-5
-60	-60	-59	-59	-59	-57	-56	-56	-55	-54	-54	-54	-50	-50	-50	-49	-49	-47	-46	-46	-45	-6
-70	-70	-69	-68	-67	-66	-66	-65	-65	-65	-63	-60	-60	-59	-58	-57	-56	-55	-54	-53	-52	-7
-80	-80	-79	-78	-78	-76	-76	-75	-75	-74	-73	-72	-71	-70	-69	-66	-65	-65	-64	-63	-62	-8
-90	-90	-89	-89	-89	-88	-88	-87	-86	-85	-83	-83	-82	-81	-80	-79	-79	-78	-77	-77	-77	-9
-100	-100	-99	-98	-97	-96	-95	-94	-95	-93	-91	-90	-89	-89	-88	-88	-86	-84	-83	-83	-82	-10
-110	-110	-108	-109	-107	-106	-106	-106	-104	-104	-104	-103	-104	-103	-102	-101	-98	-96	-93	-92	-91	-11
-120	-120	-120	-120	-119	-119	-119	-116	-115	-115	-113	-112	-111	-109	-108	-106	-106	-105	-105	-105	-104	-12
-130	-130	-130	-130	-129	-129	-129	-129	-128	-127	-126	-124	-123	-122	-120	-120	-118	-118	-116	-115	-114	-13
-140	-140	-139	-139	-138	-137	-137	-137	-135	-134	-131	-131	-131	-130	-130	-130	-129	-128	-126	-125	-123	-14
-151	-150	-151	-150	-148	-146	-145	-144	-141	-139	-137	-139	-138	-137	-137	-136	-135	-134	-133	-131	-130	-15
-160	-160	-160	-157	-156	-154	-153	-152	-151	-150	-150	-150	-149	-149	-148	-146	-145	-144	-143	-142	-141	-16
-170	-170	-170	-170	-169	-168	-168	-167	-166	-165	-162	-161	-160	-160	-158	-156	-156	-154	-152	-150	-149	-17
-180	-180	-179	-177	-176	-176	-176	-175	-174	-173	-171	-169	-168	-167	-165	-164	-163	-160	-159	-158	-158	-18
-190	-189	-188	-188	-187	-187	-186	-186	-185	-184	-183	-182	-179	-178	-177	-176	-176	-173	-173	-173	-172	-19
-200	-198	-198	-198	-196	-196	-195	-194	-194	-194	-193	-190	-188	-188	-186	-185	-184	-184	-184	-183	-183	-20

POUNDS OF NORMAL FORCE

THIS TABLE INDICATES THE 'AXIAL' READOUT, IN COUNTS, WHEN THE BALANCE WAS LOAD ED UNDER THE ABOVE CONDITIONS. THE NEGATIVE OUTPUT WAS MIRRORED TO PRODUCE A NEGATIVE QUADRANT. THE MAPPING THAT RESULTED WAS USED TO CORRECT THE NORMAL DATA COLLECTED DURING TEST RUNS.

```
C
C                CHRISTOPHER L. SAMPLES, CAPTAIN, USAF
C
C          "THE INFLUENCE OF HELICOPTER TAIL SHAPE ON FLIGHT
C                        AN AERODYNAMIC ANALYSIS
C                        USING A LOW SPEED WIND TUNNEL"
C
C          FORTRAN PROGRAM TO REDUCE WIND TUNNEL DATA TO
C          USEABLE FORM FOR USE IN SIKORSKY PROGRAM (AVO
C          FOR CURVE FITTING.
C
C     DEFINITION OF VARIABLES USED IN THIS PROGRAM
C
C     AA        ANGLE OF ATTACK IN RADIANS
C     AREAD     AREA USED FOR COEFFICIENT OF DRAG, AS
C               CROSSECTIONAL AREA OF FUSELAGE. SAME FOR ALL
C               9 MODELS
C     AREAL     AREA USED FOR COEFFICIENT OF LIFT, IN WHICH
C               AREA OF FUSELAGE DIFFERS FOR EACH
C               CONFIGURATION
C     ACA       ANGLE OF ATTACK
C     CALN,     TABLE OF BALANCE DATA THAT WAS USED TO
C     CALA      TO ALLOW FOR CORRECTING CN & CA. WHEN BALANCE
C               WAS CALIBRATED IT WAS ONLY LOADED IN ONE
C               DIRECTION (+ AXIAL,- NORMAL) AND A LINEARITY
C               TABLE WAS GENERATED ASSUMING ELASTIC
C               PROPERTIES WOULD PRODUCE THE SAME RESULTS
C               UNDER COMPRESSIVE AS WELL AS TENSILE FORCES
C     CCN,      CN & CA CORRECTED FOR BALANCE INTERACTION
C     CCA
C     CFN,      CORRECTION FACTOR USED TO OBTAIN LOW PASS FILTERED
C               READING
C     CFA       IN LINE WITH RAW DATA READING A FOR EACH DATA
C               RUN
C     CN,CA     NUMBER OF COUNTS FROM DIGITAL READOUT PANEL
C               FOR A PARTICULAR MODEL AT AN ANGLE OF ATTACK
C               AND WIND SPEED
C     CCEFFL,   COEFFICIENTS OF LIFT/DRAG, AND
C     CCEFFD
C     EFPA      EQUIVALENT FLAT PLATE AREA (SQ FT)
C     ICNTSL,   COUNTS OF NORMAL AND AXIAL FORCE CONVERTED TO
C     ICNTSD    COUNT OF LIFT AND DRAG
C     INTER     INTERPOLATION VARIABLE(DUMMY) USED TO LOCATE
C               ACTUAL AXIAL OR NORMAL COUNTS BETWEEN COUNTS
C               IN BALANCE INTERACTION TABLES(APP A)
C     K,L,N,    COUNTERS USED IN VARIOUS LOOPS
C     J
C     NT        MODEL/TAIL COMBINATION USED IN WIND TUNNEL
C     Q         DYNAMIC PRESSURE
C     RCA,      COUNTS CONVERTED TO TOTAL NUMBERS
C     RCN
C     RCCA,     COUNTS OF AXIAL AND NORMAL FORCE CORRECTED FOR
C     RCCN      BALANCE INTERACTION
C     RE        REYNOLDS NUMBER
C     X(),Y()   DUMMY COORDINATES CONVERTED FROM PROJECT PLOTS
C               FOR CURVES USED IN DIGITIZING CURVES TO DATA
C
C
      INTEGER NT(29),CRN(29,1),CRA(29,1),ZA(29,1),
     *ZFA(29,1),CN(29,41),CA(29,41),ICNTSL(29,40),
     *ICNTSD(29,40),ACA(29,40),J,K,L,N,Q,CALN(41,21),
     *CALA(41,21),CCN(29,40),CCA(29,40)
C
```

Figure A.9 FORTRAN Program for Data Conversion

```
      REAL M,1A(29,40),CC(29,40),CA(29,40),CATSO(29,40),
     *CNTSO(29,40),RE(29,40),X(10),Y(10),CAPFL(29,40),
     *CCLFFD(29,40),Q(29,40),LL,INT ,R CA(29,40)
C
      COMMON WORK(5000)
C
      DO 5 L = 21,29
      CALL READIR(INT,CFN,CFA,ZFN,ZFA,NA,CN,CA,L)
    5 CONTINUE
C
      DO 57 L = 1,41
         CALL RDA2(CALN,CALA,L)
   57 CONTINUE
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      DO 100 N = 21,29
      NN = N - 20
      WRITE(3,48)NN
   48 FORMAT('1',/,20X,'NOSE/TAIL COMBINATION',I3)
      WRITE(3,39)
   39 FORMAT(1X,/,1X,'    APA   CN   CA CCN CCA   IL   IO     CL
     *'CD          RE            Q    WEIGHT',/)
CCCC  WEIGHTS OF NOSE/ TAIL COMBINATIONS CCCCCCCCCCCCCCCCCCC
      A = 6. + 128./453.6
      B = 4. + 374./453.6
      S = 4. + 139./453.6
      H = 6. + 120./453.6
      M = 4. + 163./453.6
      LL= 6. + 120./453.6
      C = 12.+  67./453.6
      IF(N.EQ.21) W = A+C+H
      IF(N.EQ.22) W = A+C+M
      IF(N.EQ.23) W = A+C+LL
      IF(N.EQ.24) W = B+C+H
      IF(N.EQ.25) W = B+C+M
      IF(N.EQ.26) W = B+C+LL
      IF(N.EQ.27) W = S+C+H
      IF(N.EQ.28) W = S+C+M
      IF(N.EQ.29) W = S+C+LL
CCCCCCCCC  REYNOLDS NUMBERS FOR Q'S OF 10,30,50,70 CCCCCCCCC
      RHO = .002377
      RLNGTH = 3.
      RMU = .00000037373
      V1 = 91.73
      V2 = 153.9
      V3 = 205.1
      V4 = 242.7
      DO 25 K = 1,40
      IF(K.LE.40) RE(N,K) = (RHO*V4*RLNGTH)/RMU
      IF(K.LE.30) RE(N,K) = (RHO*V3*RLNGTH)/RMU
      IF(K.LE.20) RE(N,K) = (RHO*V2*RLNGTH)/RMU
      IF(K.LE.10) RE(N,K) = (RHO*V1*RLNGTH)/RMU
CCCCCCCCC  ASSIGNING Q VALUES  CCCCCCCCCCCCCCCCCCCCCCCCCCC
      IF(K.LE.40) Q(N,K) = 70.
      IF(K.LE.30) Q(N,K) = 50.
      IF(K.LE.20) Q(N,K) = 30.
      IF(K.LE.10) Q(N,K) = 10.
CCCCCCCCCC  CORRECTING COLLECTED DATA FOR BALANCE ERROR.
C           USING CALN & CALA TABLES TO CORRECT.
C           CN & CA CHANGED TO REAL NUMBERS.
      RCN(N,K) = FLOAT(CN(N,K))
      RCA(N,K) = FLOAT(CA(N,K))
CCCCCCCCCC  CORRECTION FOR AXIAL COUNT INITIALLY ASSUMING
C           NORMAL COUNT IS ACCURATE.
```

Figure A.9 FORTRAN Program for Data Conversion(cont'd)

```
C              J IS COLUMN IN CALA THAT RELATES TO
C              CALIBRATION AT POINT, I.E. J=1 IS CLOSE TO CALIB
C              COLUMN 1 (J IS USED TO INTERPOLATE)
      J = (INT(ABS(RCA(N,K)/10.-.5)) + 2
      IF(RCA(N,K).LT.-5.) J = INT(ABS(RCA(N,K)/10.)-.5) + 1
      DO 220 L = 1,40
      IF(RCA(N,K).LE.CALA(L,J).AND.RCA(N,K).GT.CALA(L+1,J))
     *GO TO 215
      GO TO 220
  215 INTER = (CALA(L,J)-RCA(N,K))/(CALA(L,J)-CALA(L+1,J))
      CCA(N,K) = INT((CALA(L,1)-INTER*10.)-.5)+1
  220 CONTINUE
CCCCCCCCCC  CORRECTION FOR NORMAL COUNT HAVING CLOSEST
C              AXIAL COUNT
      J = INT(ABS(CCA(N,K)/10.)-.5) + 2
      IF(CCA(N,K).LT.-5.) J = INT(ABS(CCA(N,K)/10.)-.5) + 1
      DO 260 L = 1,40
      IF(RCN(N,K).LE.CALN(L,J).AND.RCN(N,K).GT.CALN(L+1,J))
     *GO TO 255
      GO TO 260
  255 INTCR = (CALN(L,J)-RCN(N,K))/(CALN(L,J)-CALN(L+1,J))
      CCN(N,K) = INT((CALN(L,1)-INTER*10.)-.5)+1
  260 CONTINUE
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCCCCCC  CONVERTING TO CCL TO BE LIFT AND DRAG FROM CALIB
C              OF NORMAL AND AXIAL FORCE.
      AA(N,K)    =((FLOAT(ACS(N,K)))/100.)*2.1459
      CNTSL(N,K)=(FLOAT(CCS(N,K))-((A-SIGN(FA(N,K)))*10.))
     *              *COS(AA(N,K))
     *              -(FLOAT(CCA(N,K))-((  *SIGN(FA(N,K)))*10.))
     *              *SIN(AA(N,K))
      CNTSD(N,K)=(FLOAT(CCA(N,K))-((A-SIGN(FA(N,K)))*10.))
     *              *SIN(AA(N,K))
     *              +(FLOAT(CCS(N,K))-((  SIGN(FA(N,K)))*10.))
     *              *COS(AA(N,K))
      ICNTSL(N,K) = INT(CNTSL(N,K)-.5)+1
      IF(CNTSL(N,K).LE.0.5) ICNTSL(N,K) = INT(CNTSL(N,K)-.5)
      ICNTSD(N,K) = INT(CNTSD(N,K)-.5)+1
      IF(CNTSD(N,K).LE.0.5) ICNTSD(N,K) = INT(CNTSD(N,K)-.5)
      AREAD = 60./144.
      AREAL = 160./144.
      COEFFD(N,K) = (CNTSD(N,K)/10.)/(W(N,K)*
      COEFFL(N,K) = (CNTSL(N,K)/10.)/(W(N,K)*
      CC = INT(CCN(N,K))
      WRITE(3,40)ALPHA(N,K),CCA(N,K),CCS(N,K)
     *,CCN(N,K),CCN(N,K),ICNTSL(N,K),ICNTSD(N,K),
     *COEFFL(N,K),COEFFD(N,K),RA(N,K),Q(N,K)
   40 FORMAT(1X,I5,1X,6I4,2F7.3,1X,F10.3,1X,I4,F8.2)
      IF(K.EQ.10.OR.K.EQ.20.OR.K.EQ.30) WRITE (3,45)
   45 FORMAT(1X,' ')
   25 CONTINUE
  100 CONTINUE
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      CALL TEK610
      CALL COMPAS
      CALL MESBUF
      CALL HWRCT ('ALTO')
      CALL HWSCAL ('SCALE')
      CALL PAGE(8.5,11.0)
      CALL SWISS
      CALL GRID(0.,1,0.002,1)
      CALL PHYSOR(2.,7.5)
      CALL AREA2D(5.0,2.5)
      CALL MESSAG('ATTACK ANGLE',11,.5,2.0)
      CALL MESSAG('M = 30 PSF',10,1.5,2.5)
```

Figure A.9 FORTRAN Program for Data Conversion(cont'd)

```
      CALL XNAME('          $',100)
      CALL YNAME('                $',100)
      CALL XINTAX
      CALL YINTAX
      CALL GRAF(-12.,2.,12.,-.05,.1,.4)
      CALL GRID(1,1)
      CALL THKCRV(.02)
      DO 101 L = 21,25
      IF(L.EQ.22) CALL DASH
      IF(L.EQ.23) CALL DOT
      CALL CURVES(X,Y,AA,COEFFD,L)
      CALL DCMCM(5000)
      CALL SMOOTH
      CALL CURVE(X,Y,10,1)
  101 CONTINUE
      CALL RESET('DOT')
      CALL ENDGR(0)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      CALL PHYSOR(2.0,4.7)
      CALL AREA2D(5.0,2.5)
      CALL MESSAG('PLUNT MOST$',10,.5,2.0)
      CALL ANAME('                $',100)
      CALL YNAME('COEFFICIENT OF DRAGS',100)
      CALL XINTAX
      CALL YINTAX
      CALL RESET('THKCRV')
      CALL GRAF(-12.,2.,12.,-.05,.1,.4)
      CALL GRID(1,1)
      CALL THKCRV(.02)
      DO 102 L = 25,26
      IF(L.EQ.25) CALL DASH
      IF(L.EQ.26) CALL DOT
      CALL CURVES(X,Y,AA,COEFFD,L)
      CALL CURVE(X,Y,10,1)
  102 CONTINUE
      CALL RESET('DOT')
      CALL ENDGR(0)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      CALL PHYSOR(2.0,1.0)
      CALL AREA2D(5.0,2.5)
      CALL MESSAG('SMOOTH ... $',11,.5,2.0)
      CALL XNAME('          $',100)
      CALL YNAME('                $',100)
      CALL MESSAG('ANGLE OF ATTACK(DEGS)$',21,1.5,-0.5)
      CALL XINTAX
      CALL YINTAX
      CALL RESET('THKCRV')
      CALL GRAF(-12.,2.,12.,-.05,.1,.4)
      CALL GRID(1,1)
      CALL THKCRV(.02)
      DO 103 L = 27,29
      IF(L.EQ.28) CALL DASH
      IF(L.EQ.29) CALL DOT
      CALL CURVES(X,Y,AA,COEFFD,L)
      CALL CURVE(X,Y,10,1)
  103 CONTINUE
      CALL ENDGR(0)
      CALL PAGE(8.5,11.0)
      CALL SWISSM
      CALL SETCHR(90.,1,0.002,1)
      CALL PHYSOR(2.0,7.2)
      CALL AREA2D(5.0,2.5)
      CALL ENDPL(0)
      CALL DONEPL
      STOP
      END
```

Figure A.9 FORTRAN Program for Data Conversion(cont'd)

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      SUBROUTINE [illegible](NT,CFN,CFA,ZFN,ZFA,AA,CN,CA,L)
      INTEGER NT(29),CFN(29,1),CFA(29,1),ZFN(29,1),
     *ZFA(29,1),AA(29,40),CN(29,40),CA(29,40),K,L,N
      READ(L,19) NT(L)
      READ(L,20) CFN(L,1),CFA(L,1)
      READ(L,21) ZFN(L,1),ZFA(L,1)
      READ(L,22) (AA(L,K),CN(L,K),CA(L,K),K=1,40)
   19 FORMAT(10X,I1)
   20 FORMAT(1X,/,1X,I3,6X,I3)
   21 FORMAT(1X,I3,6X,I3)
   22 FORMAT(1X,/,/,10(1X,I3,5X,I4,7X,I4,/),
     *             /,/,10(1X,I3,5X,I4,7X,I4,/),
     *             /,/,10(1X,I3,5X,I4,7X,I4,/),
     *             /,/, 9(1X,I3,5X,I4,7X,I4,/),1X,I3,5X,I4,7X,
     *             I4)
      RETURN
      END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      SUBROUTINE CURVES(X,Y,AA,COEFFD,L)
      REAL X(10),Y(10),AA(29,40),COEFFD(29,40)
      INTEGER L
      X(1) = AA(L,1)*(180/3.14159)
      X(2) = AA(L,2)*(180/3.14159)
      X(3) = AA(L,3)*(180/3.14159)
      X(4) = AA(L,4)*(180/3.14159)
      X(5) = AA(L,5)*(180/3.14159)
      X(6) = AA(L,6)*(180/3.14159)
      X(7) = AA(L,7)*(180/3.14159)
      X(8) = AA(L,8)*(180/3.14159)
      X(9) = AA(L,9)*(180/3.14159)
      X(10)= AA(L,10)*(180/3.14159)
      Y(1) = COEFFD(L,11)
      Y(2) = COEFFD(L,12)
      Y(3) = COEFFD(L,13)
      Y(4) = COEFFD(L,14)
      Y(5) = COEFFD(L,15)
      Y(6) = COEFFD(L,16)
      Y(7) = COEFFD(L,17)
      Y(8) = COEFFD(L,18)
      Y(9) = COEFFD(L,19)
      Y(10)= COEFFD(L,20)
      RETURN
      END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      SUBROUTINE RDR(CALNOR,CALAXS)
      INTEGER CALNOR(21,21),CALAXS(21,21)
      DO 59 N=1,21
         READ(8,20) (CALNOR(N,K),K=1,21)
   59 CONTINUE
      DO 9 N=1,21
         READ(9,20) (CALAXS(N,K),K=1,21)
    9 CONTINUE
   20 FORMAT(1X,21(I4))
      RETURN
      END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      SUBROUTINE RDR2(CALN,CALA,N)
      INTEGER CALN(41,21),CALA(41,21),N
      READ(8,119) (CALN(N,K),K=1,21)
      READ(9,119) (CALA(N,K),K=1,21)
  119 FORMAT(1X,21(I4))
      RETURN
      END
```

Figure A.9 FORTRAN Program for Data Conversion(cont'd)

INTERMEDIATE CALIBRATION AND EQUIPMENT SETUP STEPS

Step No.

1. Turn on all electrical equipment for approximately 10 min.

2. Zero angle of attack reading (AOA).

3. Record model configuration.

4. Install calibration rigging.

5. Zero normal axial component reading on channel #2 amplifier.

6. Zero raw axial component reading on channel #3 amplifier.

7. Zero normal & axial signal conditioner LP adjustment.

8. Place 10 lbs. weight under model on rigging to set Raw normal channel to span of -.0100 counts on voltmeter #1.
   RN: -10# - -.0100

9. Check & record conditioned normal signal.
   CN: .0100 approximately.

10. Place 10 lbs. weight on axial rigging to set raw axial channel to span of +.0100 on voltmeter #2.
    RN: +10# = +.0100

11. Record as counts: conditioned normal (CN).
    example: -.0100 is -100 counts.
    conditioned axial (CA).
    example: +.0100 is 100 counts.

12. Remove calibration rigging from model.

13. Re-zero angle of attack (AOA).

14. Re-zero raw normal & raw axial channels (should check conditioned normal & conditioned axial to ensure close to raw readings).

Figure A.10 Data Collection Checklist

15. Use DATA RECORD provided and note nose/tail combination number in the first line.

16. Set junction box switches to conditioned normal (CN) and conditioned axial (CA). Both should read ".0000".

17. Ensure all tools and loose equipment is removed from the tunnel and doors are secure.

18. Start tunnel with model at eight degrees AOA.

19. Set Q (speed) of the tunnel. (10,30,50,70)

20. Vary AOA and record counts axial & normal (conditioned).

21. Return model to zero AOA and turn off tunnel motors.

22. Re-zero normal & raw axial channels if necessary.

23. Check and record temperature of the tunnel. Allow tunnel to cool to approximately the same temperature as the start up temperature of the tunnel.
*note: axial channel is very susceptible to large temperature variations.

24. When temperature stabilizes, prepare to continue to next higher Q (speed).

25. Go to step #16 and continue.

Figure A.10 Data Collection Checklist(cont'd)

```
        NOSE/TAIL COMBINATION  1   (ATTACK/HIGH)
                        WEIGHT = 24.7 LBS
                        Q=10     RE=.1758+07
 AOA    CN     CA    CCN    CCA     II   ID      CL       CD       EFFA
   8     6     39      6     37      3    3   0.020    0.075    0.031
   6     3     38      3     38      1    2  -0.013    0.056    0.023
   4    -1     20      0     20     -1    3  -0.007    0.065    0.027
   2    -2      8     -1      8     -1   -1  -0.010   -0.016   -0.007
   0    -5      2     -4      2     -4    2  -0.036    0.048    0.020
  -2    -8     -3     -7     -3     -7    7  -0.062    0.165    0.069
  -4    -9    -12     -8    -11     -8    7  -0.073    0.163    0.068
  -6   -10    -23     -9    -21    -10    6  -0.098    0.141    0.059
  -8   -12    -30    -11    -29    -13    7  -0.113    0.172    0.072
 -10   -14    -45    -13    -44    -17    2  -0.150    0.043    0.018

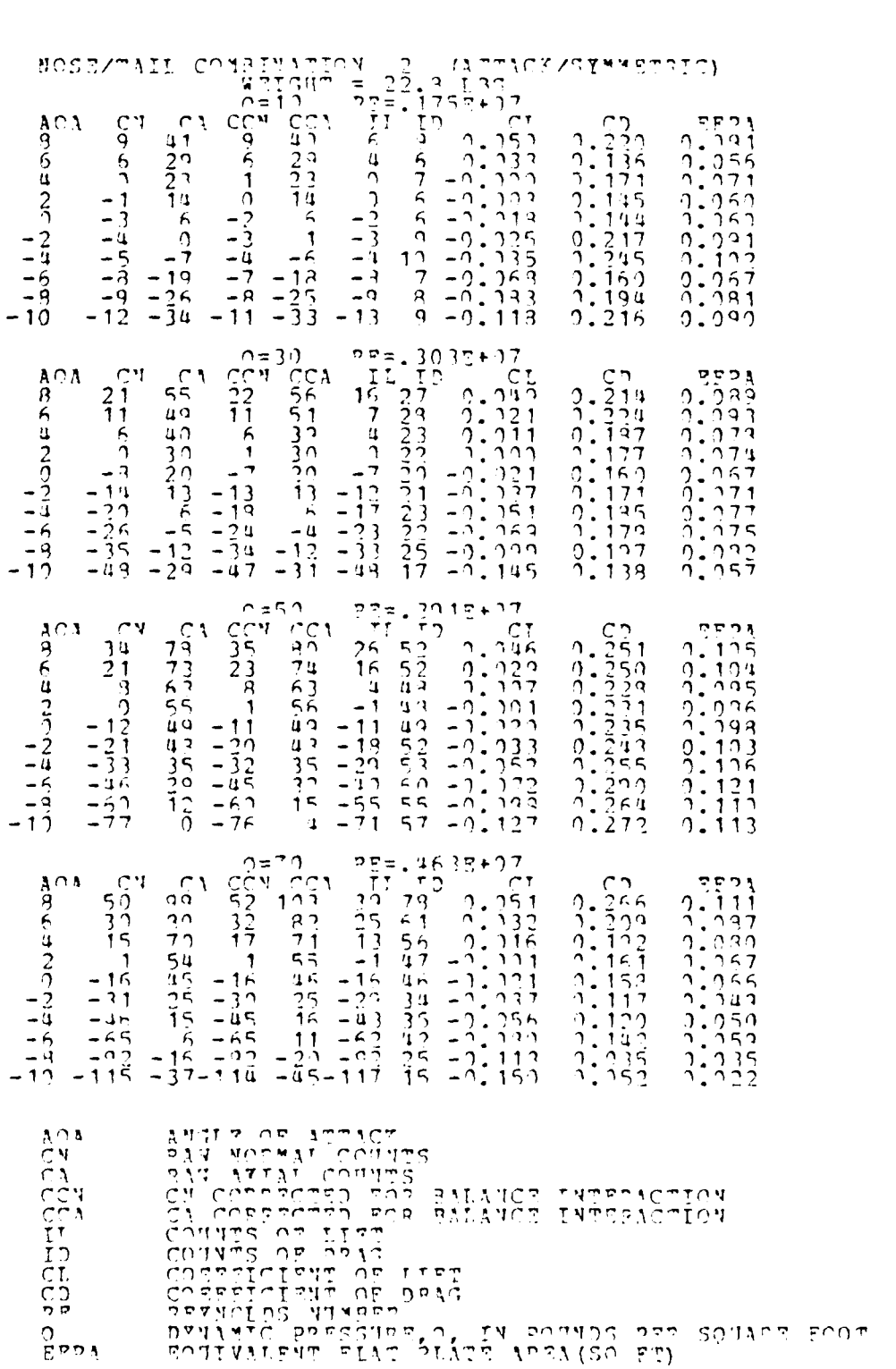
                        Q=30     RE=.3035+07
 AOA    CN     CA    CCN    CCA     II   ID      CL       CD       EFFA
   8    20     60     21     61     15   29   0.044    0.232    0.097
   6    13     52     13     53      9   29   0.026    0.226    0.094
   4     6     42      6     41      4   24   0.011    0.193    0.080
   2    -1     32      0     32     -1   23  -0.003    0.187    0.078
   0   -10     20     -9     20     -9   20  -0.027    0.161    0.067
  -2   -18     10    -16     10    -15   19  -0.046    0.153    0.064
  -4   -25      2    -23      2    -22   21  -0.067    0.167    0.069
  -6   -32    -10    -31     -9    -30   20  -0.091    0.161    0.067
  -8   -41    -21    -39    -29    -39   20  -0.117    0.161    0.067
 -10   -50    -35    -49    -36    -51   16  -0.152    0.127    0.053

                        Q=50     RE=.3915+07
 AOA    CN     CA    CCN    CCA     II   ID      CL       CD       EFFA
   8    38     80     38     80     24   53   0.042    0.265    0.110
   6    17     80     19     81     12   57   0.021    0.272    0.113
   4     5     74      6     74      1   57   0.003    0.274    0.114
   2    -5     62     -4     62     -6   53  -0.011    0.255    0.106
   0   -19     53    -19     53    -19   50  -0.034    0.278    0.116
  -2   -30     45    -28     46    -27   56  -0.049    0.267    0.111
  -4   -43     35    -42     36    -39   56  -0.070    0.269    0.112
  -6   -57     23    -56     25    -52   57  -0.093    0.271    0.113
  -8   -72     10    -72     14    -67   58  -0.121    0.280    0.117
 -10   -88     -3    -86     -9    -83   49  -0.149    0.235    0.098

                        Q=70     RE=.4635+07
 AOA    CN     CA    CCN    CCA     II   ID      CL       CD       EFFA
   8    52     98     54    100     42   74   0.054    0.254    0.106
   6    31     90     31     91     23   68   0.029    0.233    0.097
   4    11     71     12     71      8   54   0.010    0.187    0.078
   2    -7     56     -6     56     -8   47  -0.010    0.162    0.067
   0   -24     40    -22     39    -23   39  -0.030    0.134    0.056
  -2   -43     25    -42     25    -41   35  -0.053    0.120    0.050
  -4   -60     13    -60     10    -58   40  -0.074    0.133    0.055
  -6   -82     -4    -81     -9    -81   25  -0.103    0.087    0.036
  -8  -104    -39   -103    -44   -106    5  -0.136    0.018    0.007
 -10  -127    -45   -126    -54   -130   12  -0.167    0.040    0.017


 AOA        ANGLE OF ATTACK
 CN         RAW NORMAL COUNTS
 CA         RAW AXIAL COUNTS
 CCN        CN CORRECTED FOR BALANCE INTERACTION
 CCA        CA CORRECTED FOR BALANCE INTERACTION
 II         COUNTS OF LIFT
 ID         COUNTS OF DRAG
 CL         COEFFICIENT OF LIFT
 CD         COEFFICIENT OF DRAG
 RE         REYNOLDS NUMBER
 Q          DYNAMIC PRESSURE,Q, IN POUNDS PER SQUARE FOOT
 EFFA       EQUIVALENT FLAT PLATE AREA(SQ FT)
```

Figure A.11 Data Output Files



```
NOSE/TAIL COMBINATION  2  (ATTACK/SYMMETRIC)
                    WEIGHT = 22.3 LBS
                    Q=10    PE=.1758+07
 AOA   CN   CA  CCN  CCA   IT   ID      CL      CD      EPPA
   8    9   41    9   40    6    3   0.051   0.220   0.091
   6    6   29    6   29    4    6   0.033   0.136   0.056
   4    3   21    1   22    0    7  -0.000   0.171   0.071
   2   -1   14    0   14    0    6  -0.003   0.145   0.060
   0   -3    6   -2    6   -2    6  -0.018   0.144   0.060
  -2   -4    0   -3    1   -3    9  -0.025   0.217   0.091
  -4   -5   -7   -4   -6   -4   10  -0.035   0.245   0.102
  -6   -8  -19   -7  -18   -8    7  -0.068   0.160   0.067
  -8   -9  -26   -8  -25   -9    8  -0.083   0.194   0.081
 -10  -12  -34  -11  -33  -13    9  -0.118   0.216   0.090

                    Q=30    PE=.3038+07
 AOA   CN   CA  CCN  CCA   IT   ID      CL      CD      EPPA
   8   21   55   22   56   16   27   0.040   0.214   0.089
   6   11   49   11   51    7   29   0.021   0.224   0.093
   4    6   40    6   39    4   23   0.011   0.187   0.078
   2    0   30    1   30    0   22   0.000   0.177   0.074
   0   -3   20   -7   20   -7   20  -0.021   0.160   0.067
  -2  -14   13  -13   13  -12   31  -0.037   0.171   0.071
  -4  -20    6  -19    5  -17   23  -0.051   0.185   0.077
  -6  -26   -5  -24   -4  -23   22  -0.068   0.179   0.075
  -8  -35  -12  -34  -12  -33   25  -0.000   0.197   0.082
 -10  -48  -20  -47  -31  -48   17  -0.145   0.138   0.057

                    Q=50    PE=.3918+07
 AOA   CN   CA  CCN  CCA   IT   ID      CL      CD      EPPA
   8   34   79   35   80   26   52   0.046   0.251   0.105
   6   21   73   23   74   16   52   0.029   0.250   0.104
   4    8   63    8   63    4   43   0.007   0.229   0.095
   2    0   55    1   56   -1   43  -0.001   0.231   0.096
   0  -12   49  -11   49  -11   43  -0.023   0.235   0.098
  -2  -21   43  -20   43  -18   52  -0.033   0.249   0.103
  -4  -33   35  -32   35  -29   53  -0.052   0.255   0.106
  -6  -46   28  -45   30  -43   60  -0.072   0.290   0.121
  -8  -60   12  -60   15  -55   55  -0.098   0.264   0.110
 -10  -77    0  -76    4  -71   57  -0.127   0.272   0.113

                    Q=70    PE=.4638+07
 AOA   CN   CA  CCN  CCA   IT   ID      CL      CD      EPPA
   8   50   98   52  103   39   79   0.051   0.266   0.111
   6   30   90   32   93   25   61   0.032   0.209   0.087
   4   15   79   17   71   13   56   0.016   0.192   0.080
   2    1   54    1   55   -1   47  -0.001   0.161   0.067
   0  -16   45  -16   46  -16   46  -0.021   0.158   0.066
  -2  -31   25  -30   25  -29   34  -0.037   0.117   0.049
  -4  -45   15  -45   16  -43   35  -0.056   0.120   0.050
  -6  -65    6  -65   11  -62   42  -0.080   0.142   0.059
  -8  -92  -16  -92  -20  -88   35  -0.113   0.086   0.036
 -10 -115  -37 -114  -45 -117   15  -0.150   0.052   0.022


 AOA       ANGLE OF ATTACK
 CN        RAW NORMAL COUNTS
 CA        RAW AXIAL COUNTS
 CCN       CN CORRECTED FOR BALANCE INTERACTION
 CCA       CA CORRECTED FOR BALANCE INTERACTION
 IT        COUNTS OF LIFT
 ID        COUNTS OF DRAG
 CL        COEFFICIENT OF LIFT
 CD        COEFFICIENT OF DRAG
 PE        REYNOLDS NUMBER
 Q         DYNAMIC PRESSURE,Q, IN POUNDS PER SQUARE FOOT
 EPPA      EQUIVALENT FLAT PLATE AREA(SQ FT)
```

Figure A.11 Data Output Files(cont'd)

NOSE/TAIL COMBINATION 3 (ATTACK/LOW)

WEIGHT = 24.7 LBS

Q=10 PF=.175E+07

AOA	CN	CA	CCN	CCA	FL	FD	CL	CD	EFFA
8	11	42	11	41	3	3	0.063	0.186	0.078
6	7	35	7	33	5	5	0.047	0.114	0.049
4	4	22	4	22	3	5	0.023	0.120	0.050
2	0	8	1	9	1	-1	0.008	-0.014	-0.006
0	-2	-3	-1	-2	-1	-2	-0.009	-0.048	-0.020
-2	-4	-7	-3	-6	-3	3	-0.029	0.065	0.027
-4	-6	-15	-5	-14	-5	4	-0.048	0.087	0.036
-6	-7	-27	-6	-26	-7	1	-0.066	0.014	0.006
-8	-9	-38	-8	-37	-11	-1	-0.096	-0.028	-0.012
-10	-11	-49	-10	-47	-14	-2	-0.128	-0.041	-0.017

Q=30 PF=.393E+07

AOA	CN	CA	CCN	CCA	FL	FD	CL	CD	EFFA
8	30	55	30	57	24	25	0.173	0.210	0.089
6	22	49	23	50	19	26	0.097	0.211	0.089
4	13	38	13	37	11	21	0.033	0.165	0.069
2	5	27	5	27	4	19	0.013	0.148	0.062
0	-1	18	0	18	0	14	0.0	0.112	0.047
-2	-8	6	-8	6	-8	15	-0.033	0.119	0.050
-4	-15	2	-14	2	-13	20	-0.060	0.162	0.067
-6	-21	-13	-20	-12	-20	16	-0.050	0.123	0.053
-8	-32	-28	-31	-27	-32	12	-0.096	0.096	0.040
-10	-38	-40	-37	-40	-40	10	-0.119	0.079	0.033

Q=50 PF=.981E+07

AOA	CN	CA	CCN	CCA	FL	FD	CL	CD	EFFA
8	50	82	50	85	40	57	0.172	0.272	0.114
6	36	73	37	75	30	53	0.095	0.253	0.105
4	20	62	21	63	17	47	0.031	0.226	0.094
2	3	46	3	47	7	30	0.012	0.185	0.077
0	-2	36	-1	35	-1	35	-0.002	0.163	0.070
-2	-14	30	-13	30	-12	39	-0.031	0.187	0.078
-4	-27	20	-26	20	-24	39	-0.043	0.187	0.078
-6	-39	13	-37	14	-34	44	-0.061	0.209	0.087
-8	-50	-3	-50	-3	-50	30	-0.091	0.135	0.056
-10	-68	-15	-68	-17	-66	33	-0.119	0.182	0.076

Q=70 PF=.463E+07

AOA	CN	CA	CCN	CCA	FL	FD	CL	CD	EFFA
8	71	98	73	104	61	73	0.077	0.270	0.113
6	51	90	52	93	43	72	0.056	0.247	0.103
4	29	75	31	77	25	52	0.034	0.212	0.089
2	10	60	10	60	9	53	0.010	0.177	0.074
0	-3	50	-2	49	-2	49	-0.009	0.137	0.057
-2	-23	27	-22	27	-21	36	-0.027	0.125	0.052
-4	-45	10	-43	12	-41	39	-0.053	0.110	0.046
-6	-60	-9	-58	-11	-57	21	-0.074	0.072	0.030
-8	-82	-30	-81	-33	-82	13	-0.105	0.044	0.019
-10	-104	-50	-103	-56	-107	5	-0.133	0.019	0.008

AOA ANGLE OF ATTACK
CN RAW NORMAL COUNTS
CA RAW AXIAL COUNTS
CCN CN CORRECTED FOR BALANCE INTERACTION
CCA CA CORRECTED FOR BALANCE INTERACTION
FL COUNTS OF LIFT
FD COUNTS OF DRAG
CL COEFFICIENT OF LIFT
CD COEFFICIENT OF DRAG
PF REYNOLDS NUMBER
Q DYNAMIC PRESSURE,Q, IN POUNDS PER SQUARE FOOT
EFFA EQUIVALENT FLAT PLATE AREA(SQ FT)

Figure A.11 Data Output Files(cont'd)

```
NOSE/TAIL COMBINATION  4  (BLUNT/BLUNT)
                    WEIGHT = 23.2 LBS
                    Q=10     PP=.1758E+07
 AOA    CN    CA   CCN   CCA    IL  ID      CI      CD      BPPA
   8     8    40     8    39     5   7  -0.043   0.177   0.074
   6     3    29     3    29     1   5  -0.011   0.117   0.049
   4     0    23     1    23     0   7  -0.000   0.163   0.068
   2    -2    10    -1    10    -1   2  -0.011   0.044   0.018
   0    -4     7    -3     7    -3   7  -0.027   0.168   0.070
  -2    -8    -4    -7    -3    -7   5  -0.063   0.129   0.054
  -4   -10   -10    -9    -9    -9   8  -0.081   0.189   0.079
  -6   -12   -13   -11   -17   -11   9  -0.103   0.205   0.085
  -8   -15   -20   -14   -20   -15   7  -0.139   0.157   0.066
 -10   -17   -36   -16   -34   -19  10  -0.163   0.231   0.096

                    Q=30     PP=.3038E+07
 AOA    CN    CA   CCN   CCA    IL  ID      CI      CD      BPPA
   8    30    55    30    57    24  28   0.072   0.226   0.094
   6    20    51    21    52    17  30   0.050   0.237   0.099
   4    12    40    12    39    10  34   0.029   0.183   0.076
   2     4    33     4    33     3  35   0.009   0.200   0.083
   0    -4    22    -3    22    -3  32  -0.009   0.176   0.073
  -2   -12    14   -11    14   -10  25  -0.031   0.130   0.075
  -4   -19     4   -17     4   -16  21  -0.043   0.171   0.071
  -6   -29    -6   -27    -5   -26  23  -0.073   0.177   0.074
  -8   -34   -15   -33   -14   -32  23  -0.097   0.185   0.077
 -10   -43   -25   -41   -24   -41  24  -0.123   0.191   0.079

                    Q=50     PP=.3918E+07
 AOA    CN    CA   CCN   CCA    IL  ID      CI      CD      BPPA
   8    88    89    88    91    37  64   0.067   0.302   0.126
   6    33    79    34    81    27  60   0.048   0.287   0.120
   4    19    70    21    71    17  56   0.030   0.263   0.112
   2     6    65     7    65     5  57   0.009   0.274   0.114
   0    -5    57    -4    57    -4  57  -0.007   0.274   0.114
  -2   -20    41   -19    40   -17  40  -0.031   0.234   0.097
  -4   -30    30   -31    30   -28  43  -0.051   0.232   0.097
  -6   -45    22   -43    22   -39  52  -0.070   0.248   0.103
  -8   -58    13   -58    15   -53  55  -0.096   0.265   0.111
 -10   -74     0   -74     3   -69  56  -0.124   0.270   0.112

                    Q=70     PP=.4635E+07
 AOA    CN    CA   CCN   CCA    IL  ID      CI      CD      BPPA
   8    65   110    67   114    53  59   0.063   0.303   0.126
   6    43   100    46   103    34  53   0.044   0.284   0.119
   4    22    94    23    95    17  80   0.022   0.275   0.115
   2     6    79     7    73     5  65   0.006   0.223   0.093
   0    -8    62    -7    62    -7  62  -0.009   0.213   0.089
  -2   -30    49   -29    49   -27  49  -0.035   0.153   0.070
  -4   -49    23   -48    24   -46  19  -0.059   0.149   0.062
  -6   -69    13   -68    14   -65  45  -0.083   0.155   0.065
  -8   -89     0   -89     6   -84  51  -0.108   0.173   0.072
 -10  -108   -15  -107   -20  -105  39  -0.135   0.135   0.056

 AOA       ANGLE OF ATTACK
 CN        RAW NORMAL COUNTS
 CA        RAW AXIAL COUNTS
 CCN       CN CORRECTED FOR BALANCE INTERACTION
 CCA       CA CORRECTED FOR BALANCE INTERACTION
 IL        COUNTS OF LIFT
 ID        COUNTS OF DRAG
 CI        COEFFICIENT OF LIFT
 CD        COEFFICIENT OF DRAG
 PP        PERTURBS NUMBER
 Q         DYNAMIC PRESSURE,Q, IN POUNDS PER SQUARE FOOT
 BPPA      EQUIVALENT FLAT PLATE AREA(SQ FT)
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Figure A.11 Data Output Files(cont'd)

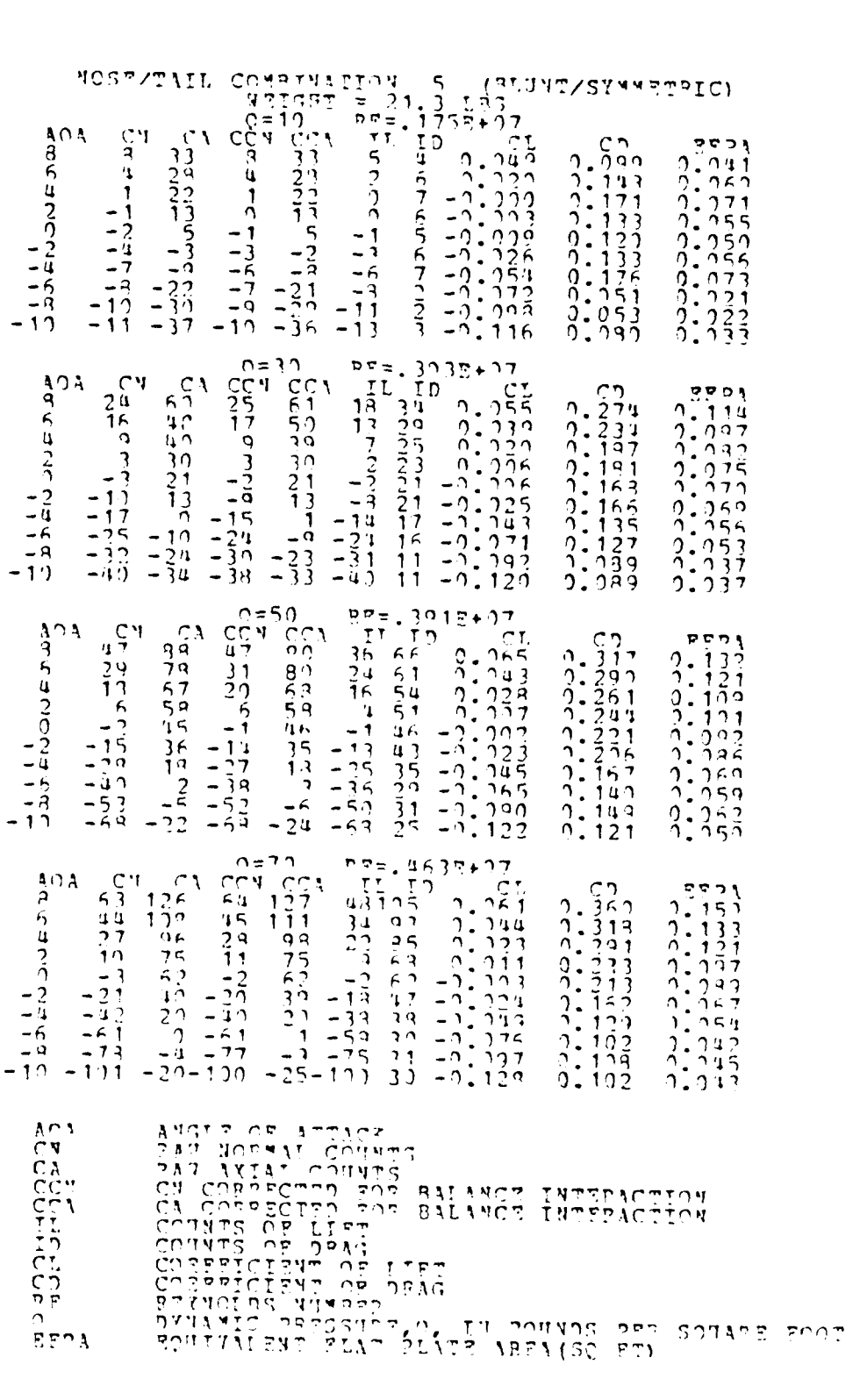


Figure A.11 Data Output Files(cont'd)

NOSE/TAIL COMBINATION 6 (BLUNT/LOW)

WEIGHT = 23.2 LBS

Q=10 PS=.1758+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	PPA
8	11	47	11	48	5	13	0.057	0.425	0.177
6	7	40	7	39	4	15	0.037	0.365	0.152
4	4	30	4	30	2	14	0.022	0.336	0.140
2	1	22	1	22	0	14	0.003	0.334	0.139
0	-1	15	0	15	0	15	0.0	0.360	0.150
-2	-3	5	-2	5	-2	13	-0.015	0.316	0.132
-4	-5	0	-4	1	-3	17	-0.030	0.420	0.175
-6	-7	-5	-6	-4	-5	21	-0.045	0.503	0.209
-8	-9	-13	-7	-17	-7	16	-0.063	0.395	0.165
-10	-9	-25	-8	-24	-9	18	-0.077	0.434	0.181

Q=30 PS=.3033+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	PPA
8	36	56	36	53	30	30	0.000	0.241	0.100
6	24	48	25	50	21	29	0.063	0.224	0.094
4	17	40	17	40	15	25	0.044	0.199	0.083
2	10	30	10	30	9	22	0.027	0.178	0.074
0	2	21	2	21	2	21	0.006	0.168	0.070
-2	-6	12	-5	12	-4	20	-0.013	0.162	0.068
-4	-13	3	-12	3	-11	20	-0.034	0.160	0.067
-6	-20	-3	-18	-2	-17	24	-0.051	0.193	0.081
-8	-30	-17	-28	-16	-23	20	-0.083	0.163	0.068
-10	-37	-25	-35	-24	-25	23	-0.105	0.182	0.076

Q=50 PS=.3015+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	PPA
8	60	85	61	88	50	63	0.091	0.304	0.127
6	47	75	47	73	40	59	0.072	0.284	0.118
4	35	65	35	63	31	54	0.055	0.269	0.108
2	20	56	21	57	19	50	0.034	0.238	0.099
0	6	47	6	48	6	43	0.011	0.235	0.098
-2	-3	38	-2	37	-1	45	-0.001	0.217	0.090
-4	-17	30	-16	30	-13	47	-0.024	0.227	0.095
-6	-30	20	-29	20	-25	47	-0.046	0.227	0.094
-8	-45	8	-43	11	-39	49	-0.070	0.236	0.098
-10	-53	0	-52	1	-48	50	-0.086	0.242	0.101

Q=70 PS=.4635+07

AOA	CN	CA	CCN	CCA	IT	ID	CL	CD	PPA
8	87	94	89	101	76	80	0.093	0.275	0.114
6	68	88	69	88	61	70	0.078	0.242	0.101
4	49	70	50	74	45	61	0.058	0.209	0.087
2	28	58	29	60	26	53	0.033	0.181	0.075
0	5	40	5	39	5	33	0.006	0.134	0.056
-2	-12	20	-11	20	-10	23	-0.013	0.098	0.041
-4	-30	3	-28	3	-27	21	-0.035	0.073	0.030
-6	-50	-10	-49	-11	-40	13	-0.052	0.053	0.022
-8	-68	-23	-68	-25	-60	17	-0.078	0.058	0.024
-10	-82	-45	-83	-51	-97	6	-0.125	0.122	0.050

AOA ANGLE OF ATTACK
CN RAW NORMAL COEFFS
CA RAW AXIAL COEFFS
CCN CN CORRECTED FOR BALANCE INTERACTION
CCA CA CORRECTED FOR BALANCE INTERACTION
IL COUNTS OF LIFT
ID COUNTS OF DRAG
CL COEFFICIENT OF LIFT
CD COEFFICIENT OF DRAG
PP DERIVED NUMBER
Q DYNAMIC PRESSURE,Q, IN POUNDS PER SQUARE FOOT
EPPA EQUIVALENT FLAT PLATE AREA(SQ FT)

Figure A.11 Data Output Files(cont'd)

```
NOSE/TAIL COMBINATION  7  (SMOOTH/HIGH)
                 WEIGHT = 22.7 LBS
                 Q=10      PP=.1752E+07
 AOA    CN    CA   CCN   CCA    TL   TD      CL       CD       EPPA
   8     8    40     3    39     5    8   0.042    0.105    0.031
   6     4    34     4    34     2   10   0.015    0.252    0.125
   4     1    26     1    26     0   10  -0.002    0.244    0.122
   2    -2    20    -1    20    -2   12  -0.014    0.289    0.139
   0    -5     7    -5     7    -5    7  -0.045    0.168    0.070
  -2    -9     2    -8     2    -8   10  -0.070    0.245    0.102
  -4   -10    -4    -9    -3    -9   13  -0.078    0.324    0.135
  -6   -13   -18   -12   -17   -12    8  -0.112    0.198    0.081
  -8   -16   -23   -14   -22   -15   12  -0.132    0.233    0.113
 -10   -19   -32   -17   -31   -19   12  -0.168    0.285    0.119

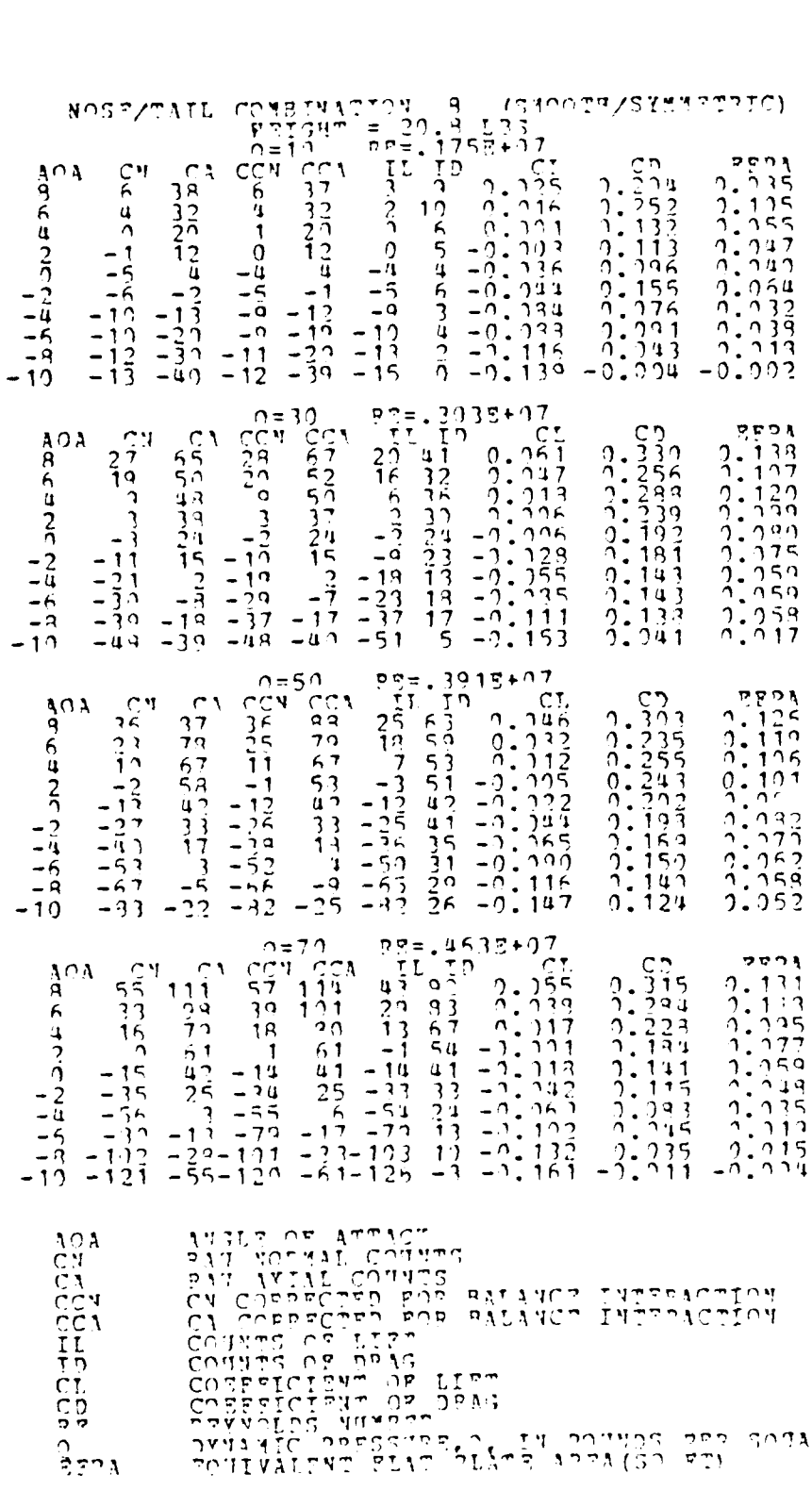
                 Q=30      PP=.3938E+07
 AOA    CN    CA   CCN   CCA    TL   TD      CL       CD       EPPA
   8    15    44    16    45    12   15   0.035    0.121    0.051
   6     3    32     3    33     5   10   0.017    0.079    0.033
   4     1    28     1    29     0   12  -0.001    0.097    0.041
   2    -3    19    -1    18    -1   10  -0.004    0.080    0.033
   0    -8     7    -7     7    -7    7  -0.021    0.056    0.022
  -2   -15    -3   -14    -2   -14    6  -0.042    0.051    0.021
  -4   -19   -12   -18   -11   -18    6  -0.055    0.049    0.020
  -6   -25   -22   -23   -21   -24    5  -0.071    0.042    0.018
  -8   -30   -35   -28   -32   -31    4  -0.093    0.032    0.013
 -10   -37   -43   -36   -45   -40    1  -0.110    0.011    0.005

                 Q=50      PP=.3915E+07
 AOA    CN    CA   CCN   CCA    TL   TD      CL       CD       EPPA
   8    32    92    42    94    31   67   0.155    0.323    0.135
   6    27    78    29    80    22   59   0.139    0.282    0.119
   4    13    70    14    70    10   55   0.117    0.264    0.110
   2     1    63     1    63    -1   55  -0.002    0.264    0.110
   0   -13    45   -12    45   -12   45  -0.023    0.216    0.090
  -2   -26    35   -25    35   -24   44  -0.043    0.210    0.088
  -4   -41    17   -39    18   -37   37  -0.067    0.175    0.073
  -6   -56     3   -55     6   -53   35  -0.095    0.170    0.071
  -8   -70    -8   -69   -11   -69   30  -0.122    0.146    0.061
 -10   -82   -20   -81   -23   -80   31  -0.145    0.148    0.062

                 Q=70      PP=.4625E+07
 AOA    CN    CA   CCN   CCA    TL   TD      CL       CD       EPPA
   8    65   114    68   119    53   95   0.168    0.335    0.135
   6    39    90    39    91    31   71   0.099    0.243    0.101
   4    20    80    22    81    17   66   0.072    0.228    0.095
   2     0    53     1    53    -1   50  -0.001    0.172    0.072
   0   -20    45   -20    46   -20   46  -0.026    0.158    0.066
  -2   -40    25   -39    25   -38   34  -0.049    0.118    0.049
  -4   -63     5   -63     3   -62   29  -0.079    0.100    0.042
  -6   -84   -12   -83   -16   -83   17  -0.107    0.057    0.024
  -8  -105   -29  -104   -36  -104   20  -0.134    0.070    0.029
 -10  -128   -37  -127   -46  -130   16  -0.167    0.056    0.023


AOA       ANGLE OF ATTACK
CN        RAW NORMAL COUNTS
CA        RAW AXIAL COUNTS
CCN       CN CORRECTED FOR BALANCE INTERACTION
CCA       CA CORRECTED FOR BALANCE INTERACTION
TL        COUNTS OF LIFT
TD        COUNTS OF DRAG
CL        COEFFICIENT OF LIFT
CD        COEFFICIENT OF DRAG
PP        REYNOLDS NUMBER
Q         DYNAMIC PRESSURE,0. IN COUNTS PER SQUARE FOOT
EPPA      EQUIVALENT FLAT PLATE AREA(SQ FT)
```

Figure A.11 Data Output Files(cont'd)



NOSE/TAIL COMBINATION 8 (S100TP/SYMMETRIC)

PITCH = 20.8 L33

Q=10 PP=.1758E+07

AOA	CM	CA	CCM	CCA	IL	ID	CL	CD	PPA
8	6	38	6	37	3	9	0.225	0.204	0.035
6	4	32	4	32	2	10	0.016	0.252	0.105
4	2	26	1	25	0	8	0.101	0.132	0.055
2	-1	12	0	12	0	5	-0.003	0.113	0.047
0	-5	8	-4	8	-4	4	-0.116	0.096	0.040
-2	-6	-2	-5	-1	-5	6	-0.044	0.155	0.064
-4	-10	-13	-8	-12	-8	3	-0.184	0.076	0.032
-6	-10	-20	-9	-19	-10	4	-0.033	0.091	0.038
-8	-12	-30	-11	-29	-13	2	-0.116	0.043	0.018
-10	-13	-40	-12	-39	-15	0	-0.139	-0.004	-0.002

Q=30 PP=.3035E+07

AOA	CM	CA	CCM	CCA	IL	ID	CL	CD	PPA
8	27	55	28	57	20	41	0.061	0.330	0.138
6	19	50	20	52	16	32	0.047	0.256	0.107
4	9	43	8	50	6	26	0.013	0.288	0.120
2	3	38	3	37	3	30	0.006	0.339	0.099
0	-3	28	-2	24	-3	24	-0.006	0.192	0.080
-2	-11	15	-10	15	-8	23	-0.128	0.181	0.075
-4	-21	2	-19	2	-18	13	-0.255	0.143	0.059
-6	-30	-8	-29	-7	-23	18	-0.235	0.143	0.059
-8	-39	-18	-37	-17	-37	17	-0.111	0.133	0.056
-10	-44	-39	-48	-40	-51	5	-0.153	0.041	0.017

Q=50 PP=.3915E+07

AOA	CM	CA	CCM	CCA	IL	ID	CL	CD	PPA
8	36	87	36	88	25	63	0.146	0.303	0.125
6	23	79	25	79	18	50	0.032	0.235	0.110
4	10	67	11	67	7	53	0.112	0.255	0.106
2	-2	58	-1	53	-3	51	-0.005	0.243	0.101
0	-15	42	-12	40	-12	42	-0.222	0.202	0.08
-2	-27	33	-26	33	-25	41	-0.044	0.193	0.080
-4	-40	17	-39	14	-36	35	-0.365	0.169	0.070
-6	-53	3	-52	4	-50	31	-0.090	0.150	0.062
-8	-67	-5	-66	-9	-65	29	-0.116	0.140	0.058
-10	-83	-22	-82	-25	-82	26	-0.147	0.124	0.052

Q=70 PP=.4563E+07

AOA	CM	CA	CCM	CCA	IL	ID	CL	CD	PPA
8	55	111	57	114	43	83	0.255	0.315	0.131
6	33	99	39	101	29	83	0.039	0.294	0.113
4	16	79	18	80	13	67	0.117	0.223	0.095
2	0	61	1	61	-1	54	-0.001	0.184	0.077
0	-15	42	-14	41	-14	41	-0.118	0.141	0.059
-2	-35	25	-34	25	-33	33	-0.042	0.115	0.048
-4	-56	3	-55	6	-54	24	-0.063	0.083	0.035
-6	-79	-13	-79	-17	-79	13	-0.102	0.045	0.019
-8	-102	-29	-101	-33	-103	10	-0.132	0.035	0.015
-10	-121	-55	-120	-61	-125	-3	-0.161	-0.011	-0.004

AOA ANGLE OF ATTACK
CM PAT NORMAL COEFFS
CA PAT AXIAL COEFFS
CCM CM COEFFICIENT FOR BALANCE INTERACTION
CCA CA COEFFICIENT FOR BALANCE INTERACTION
IL COUNTS OF LIFT
ID COUNTS OF DRAG
CL COEFFICIENT OF LIFT
CD COEFFICIENT OF DRAG
PP DYNAMIC PRESSURE, Q, IN POUNDS PER SQUARE FOOT
PPA EQUIVALENT FLAT PLATE AREA(SQ FT)

Figure A.11 Data Output Files(cont'd)

NOSE/TAIL COMBINATION 9 (SMOOTH/LOW)
WEIGHT = 22.7 LBS

Q=10 RE=.175E+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	FEPA
8	12	42	12	41	8	11	0.075	0.256	0.107
6	9	29	9	29	7	6	0.054	0.145	0.060
4	5	20	5	20	4	4	0.037	0.107	0.045
2	2	7	2	7	2	-1	0.017	-0.021	-0.009
0	0	2	1	2	1	2	0.009	0.049	0.020
-2	-2	-7	-1	-6	-1	2	-0.010	0.047	0.020
-4	-4	-19	-3	-13	-4	-2	-0.033	-0.046	-0.019
-6	-6	-24	-6	-23	-6	1	-0.055	0.034	0.014
-8	-7	-38	-6	-37	-9	-1	-0.080	-0.100	-0.042
-10	-9	-45	-8	-44	-12	-2	-0.109	-0.060	-0.025

Q=30 RE=.303E+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	FEPA
8	38	60	38	62	31	35	0.094	0.281	0.117
6	29	52	29	55	24	34	0.073	0.272	0.113
4	20	40	20	40	18	25	0.053	0.204	0.085
2	10	29	10	27	9	21	0.027	0.171	0.071
0	4	13	4	19	4	13	0.012	0.144	0.060
-2	-2	2	-1	2	-1	10	-0.002	0.080	0.033
-4	-12	-12	-11	-11	-11	6	-0.034	0.045	0.019
-6	-21	-22	-19	-21	-20	5	-0.060	0.039	0.016
-8	-30	-33	-29	-32	-31	4	-0.093	0.032	0.013
-10	-36	-47	-35	-50	-40	-4	-0.119	-0.030	-0.012

Q=50 RE=.391E+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	FEPA
8	53	83	50	86	49	62	0.098	0.296	0.124
6	44	77	45	73	38	60	0.068	0.286	0.119
4	27	63	27	64	23	50	0.041	0.239	0.100
2	14	54	14	55	12	48	0.022	0.229	0.095
0	1	39	1	39	1	33	0.002	0.182	0.076
-2	-13	26	-12	26	-11	34	-0.020	0.165	0.069
-4	-29	19	-28	18	-26	35	-0.047	0.172	0.072
-6	-43	2	-41	4	-39	32	-0.070	0.154	0.064
-8	-57	-12	-55	-14	-54	25	-0.099	0.122	0.051
-10	-72	-28	-72	-31	-73	21	-0.131	0.103	0.043

Q=70 RE=.463E+07

AOA	CN	CA	CCN	CCA	IL	ID	CL	CD	FEPA
8	83	110	87	115	72	94	0.093	0.324	0.135
6	62	90	63	93	54	75	0.070	0.253	0.103
4	42	80	41	82	36	69	0.046	0.236	0.098
2	19	54	20	55	13	48	0.023	0.164	0.068
0	0	35	1	35	1	35	0.001	0.120	0.050
-2	-21	20	-20	20	-19	30	-0.025	0.098	0.041
-4	-42	0	-40	1	-39	20	-0.051	0.067	0.029
-6	-64	-21	-64	-22	-65	9	-0.083	0.029	0.012
-8	-84	-42	-84	-43	-83	-1	-0.113	-0.014	-0.006
-10	-105	-65	-104	-71	-111	-12	-0.143	-0.043	-0.018

AOA ANGLE OF ATTACK
CN RAW NORMAL COUNTS
CA RAW AXIAL COUNTS
CCN CN CORRECTED FOR BALANCE INTERACTION
CCA CA CORRECTED FOR BALANCE INTERACTION
IL COUNTS OF LIFT
ID COUNTS OF DRAG
CL COEFFICIENT OF LIFT
CD COEFFICIENT OF DRAG
RE REYNOLDS NUMBER
Q DYNAMIC PRESSURE,Q, IN POUNDS PER SQUARE FOOT
FEPA EQUIVALENT FLAT PLATE AREA(SQ FT)

Figure A.11 Data Output Files(cont'd)

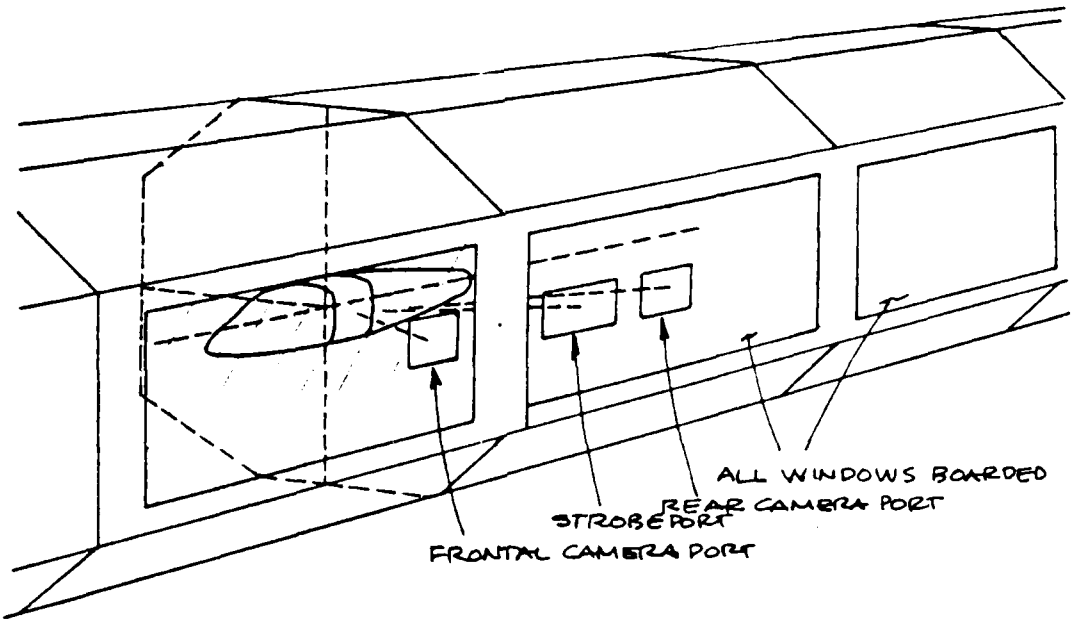


Figure A.12 Layout for Mini-tufting Photography

APPENDIX B
GRAPHICAL RESULTS

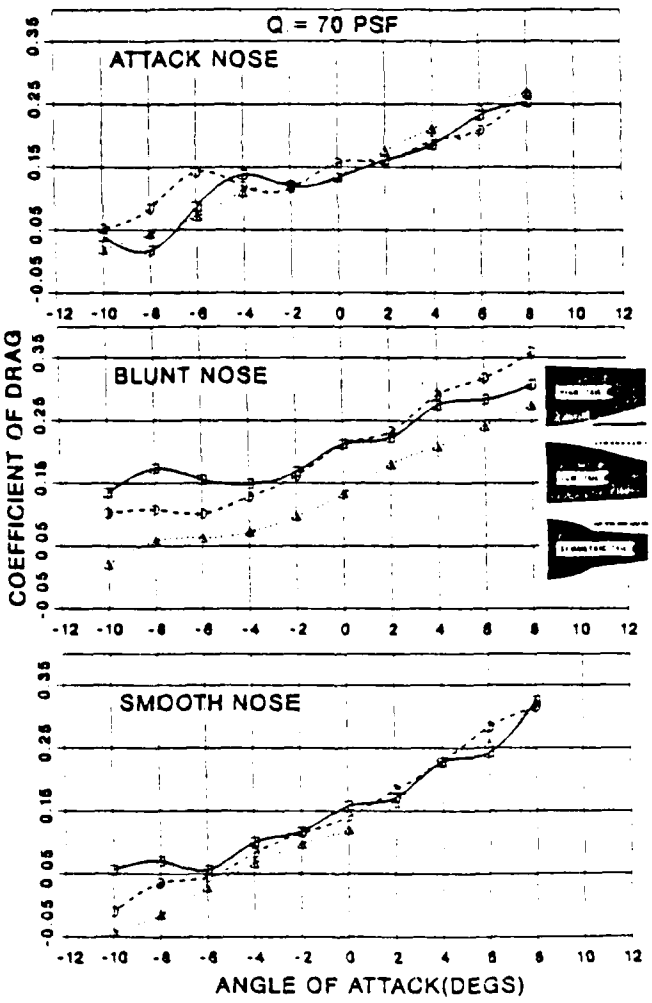


Figure B.1 Cd Versus AOA

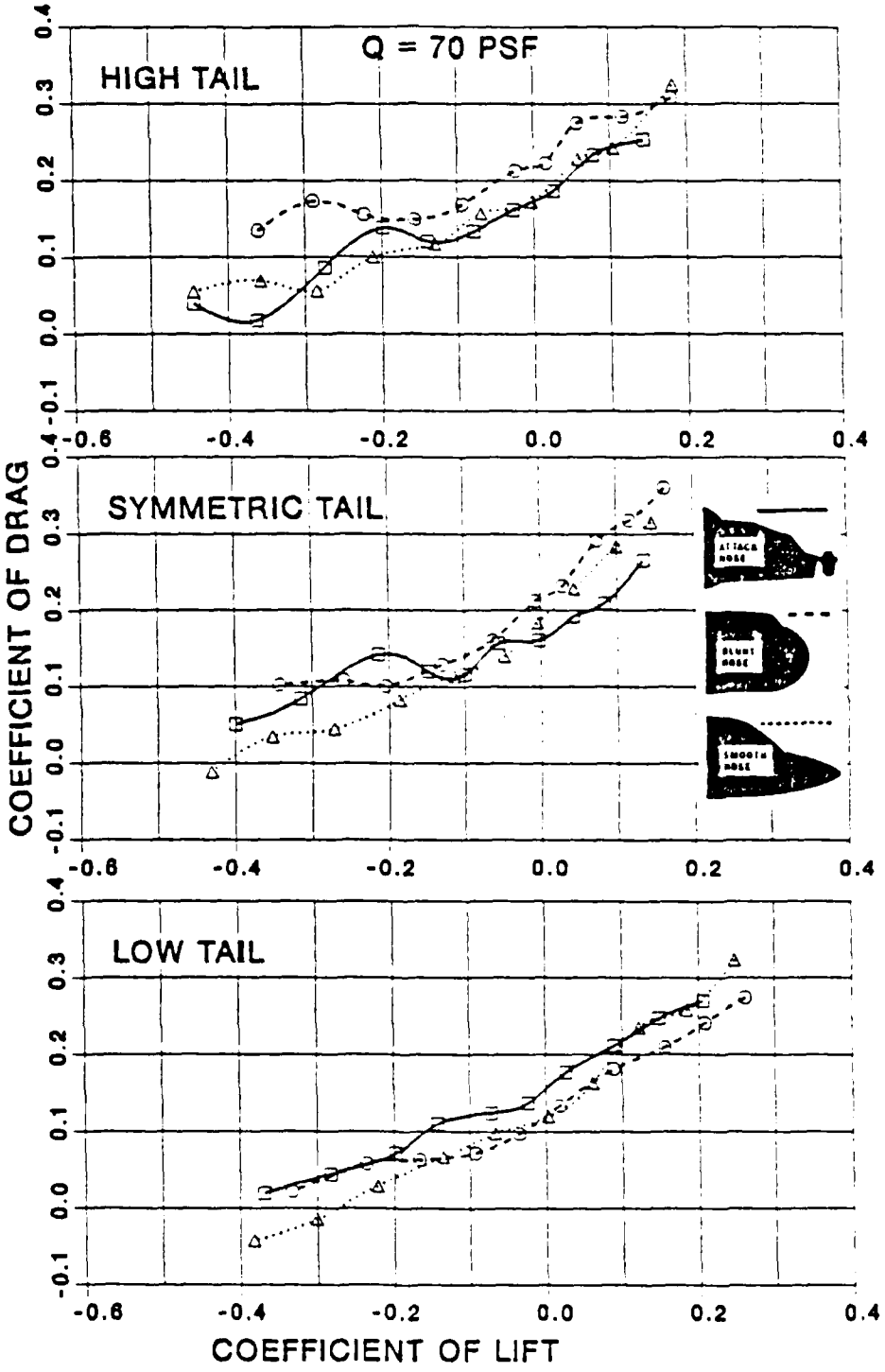


Figure B.2 Cd Versus Cl

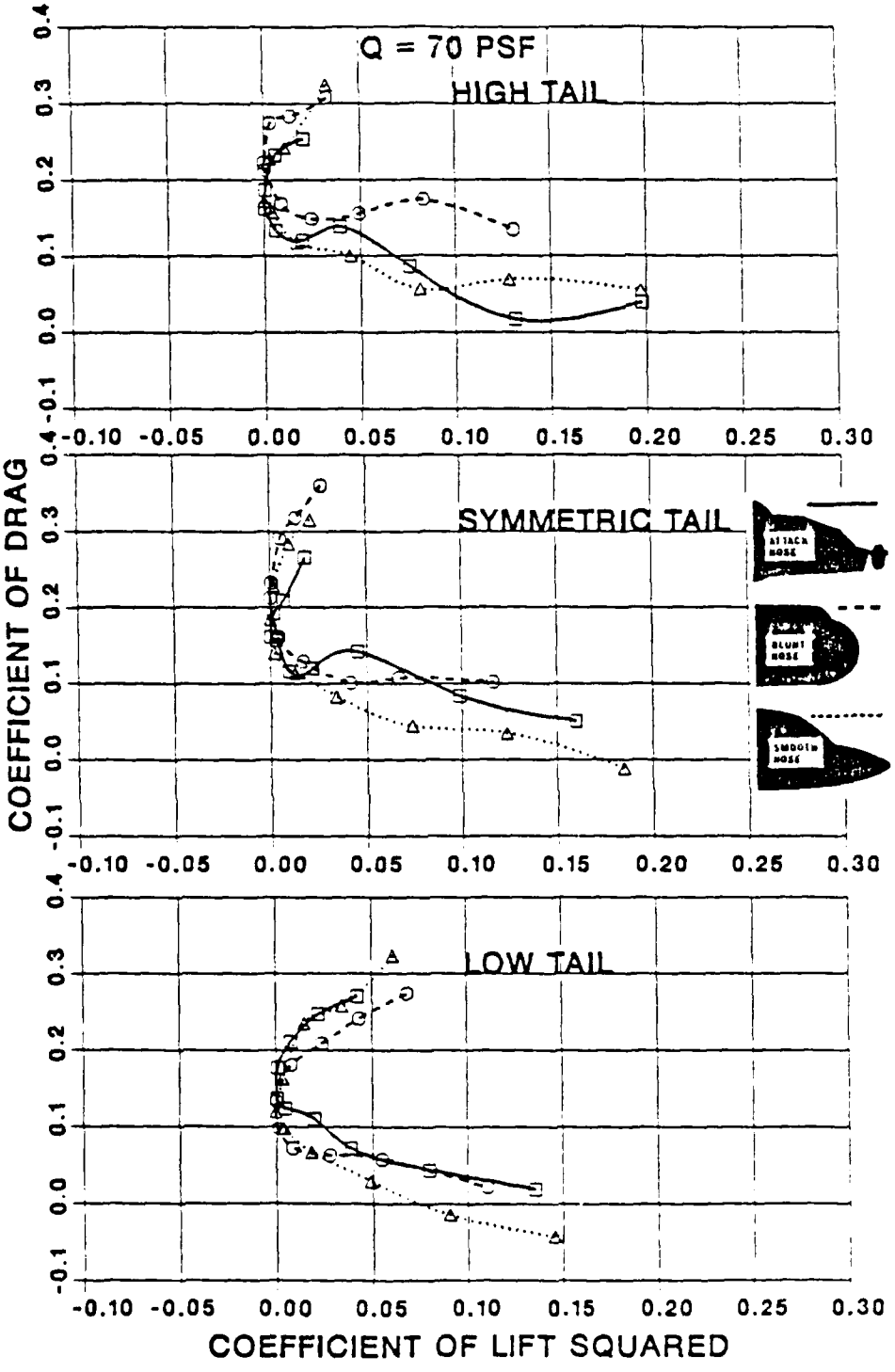


Figure B.3 Cd Versus Cl Squared

APPENDIX C
FLOW VISUALIZATION RESULTS

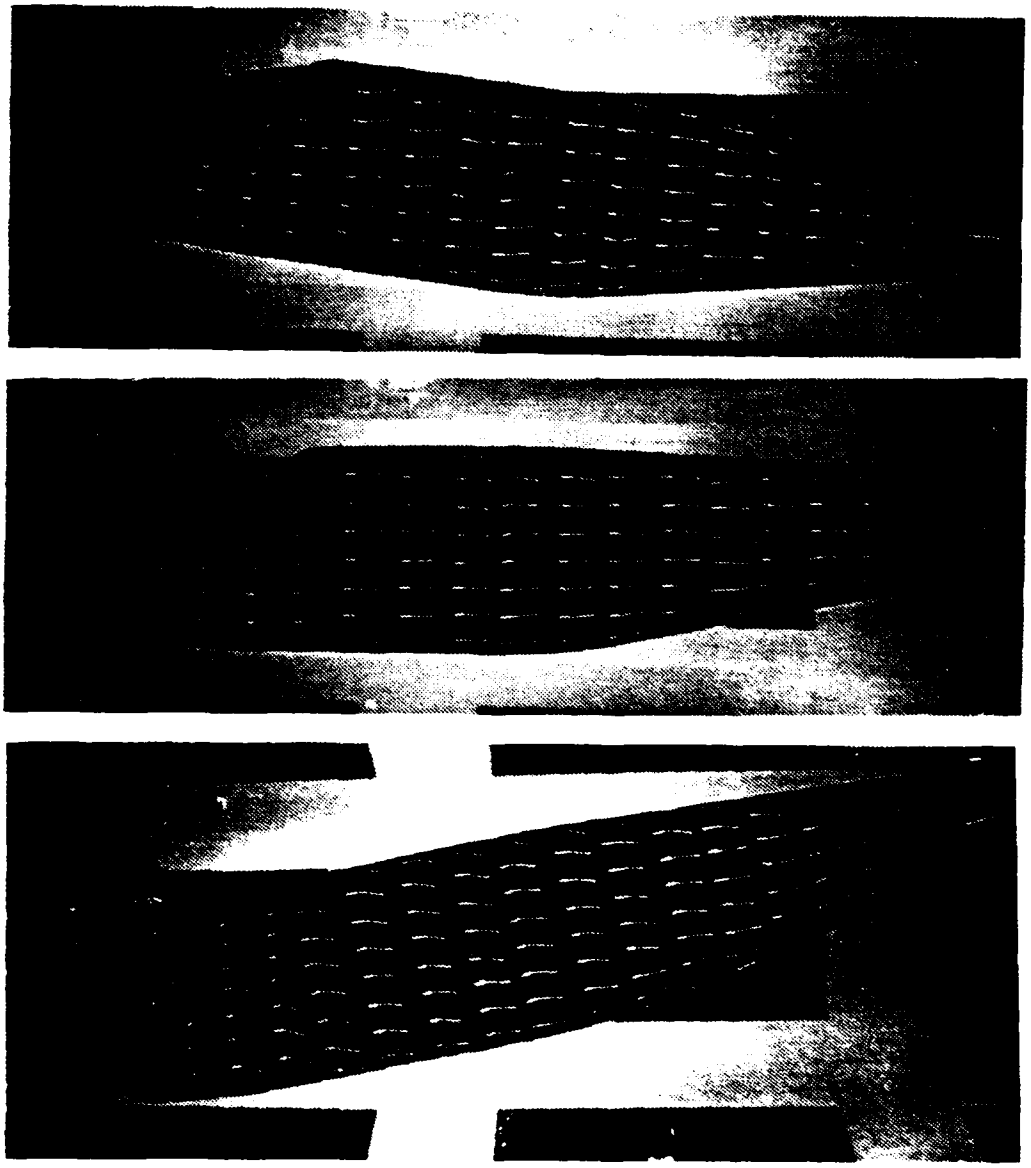


Figure C.1 Attack Nose/ High Tail

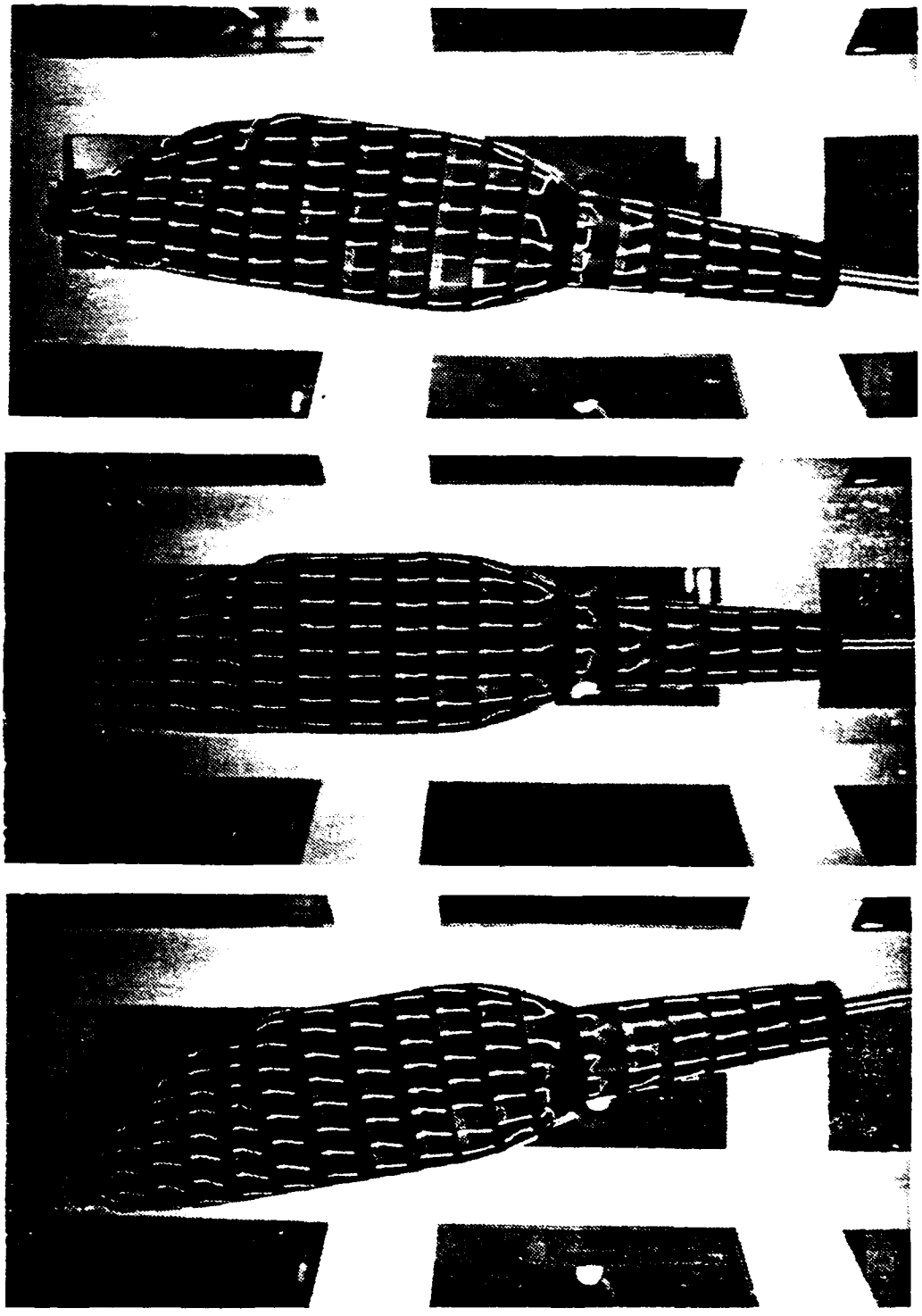


Figure C.2 Attack Nose/ Symmetric Tail

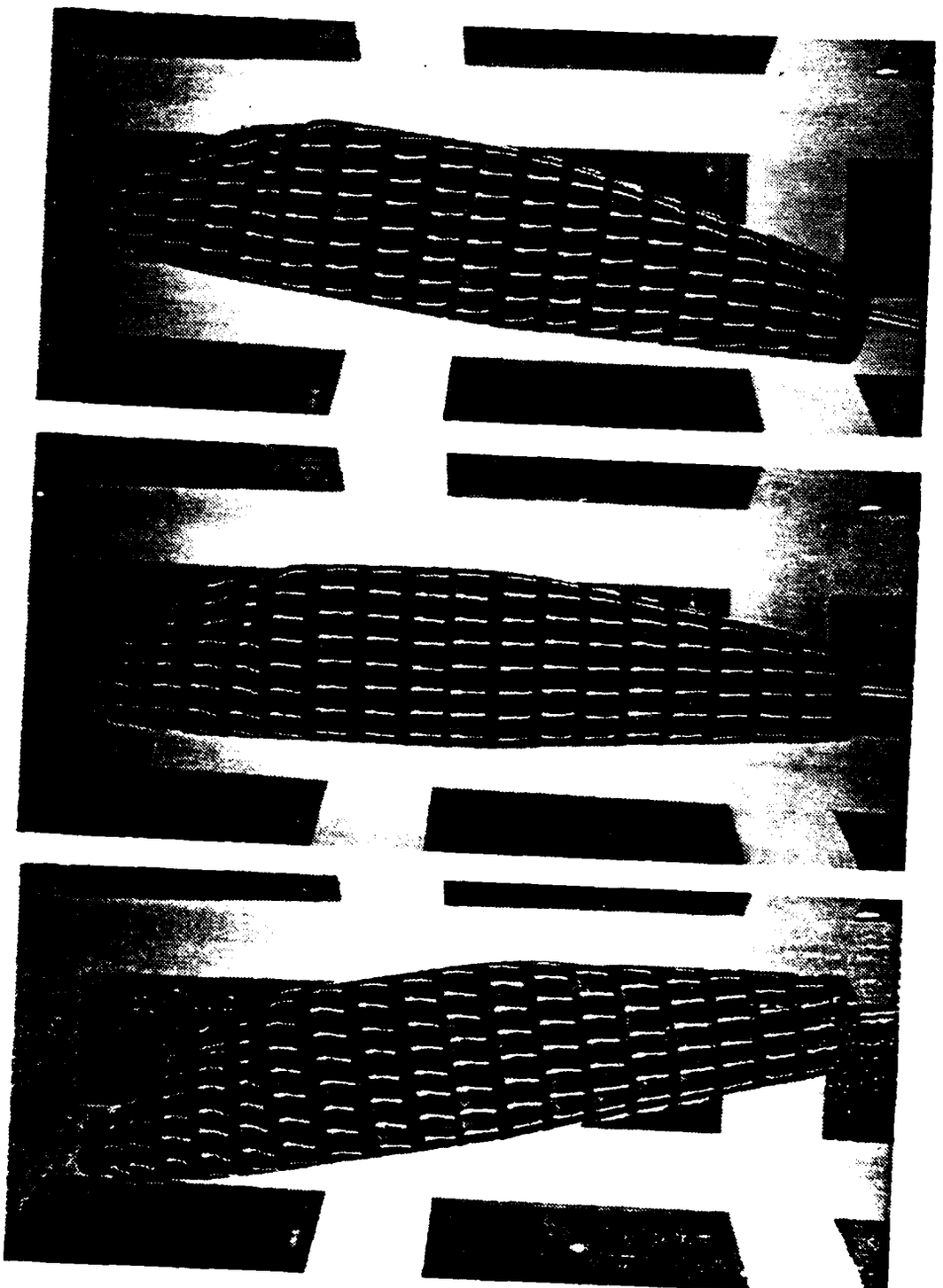


Figure C.3 Attack Nose Low Tail

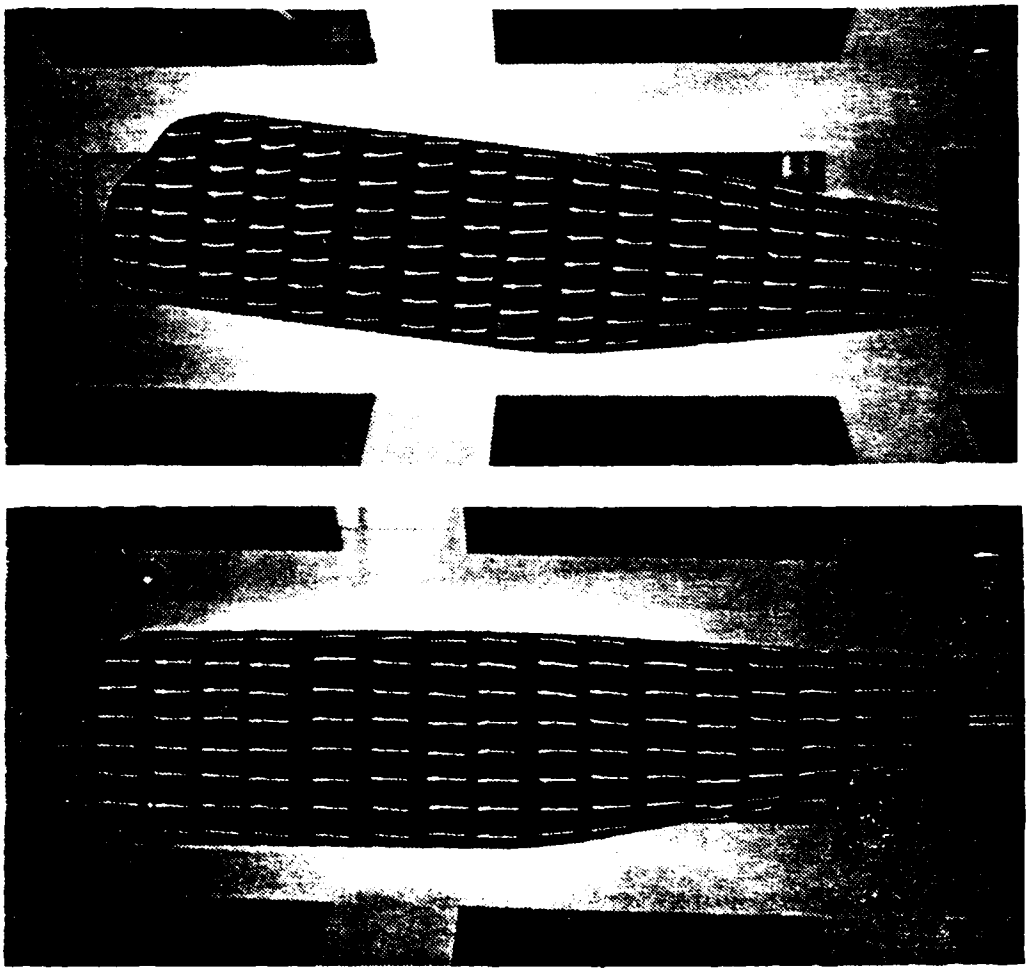


Figure C.1 Blunt Nose High Tail

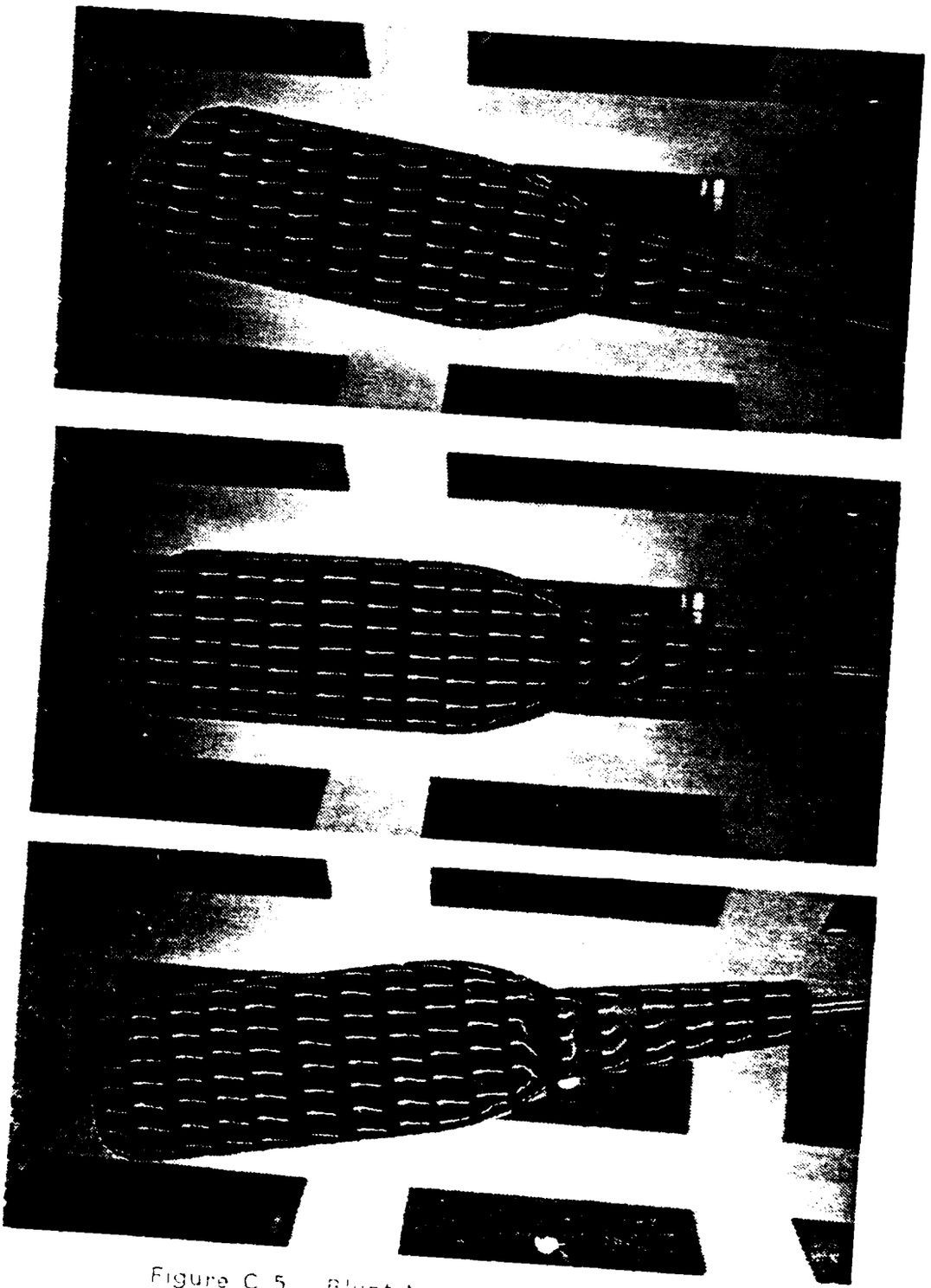


Figure C.5 Blunt Nose Symmetric Tail

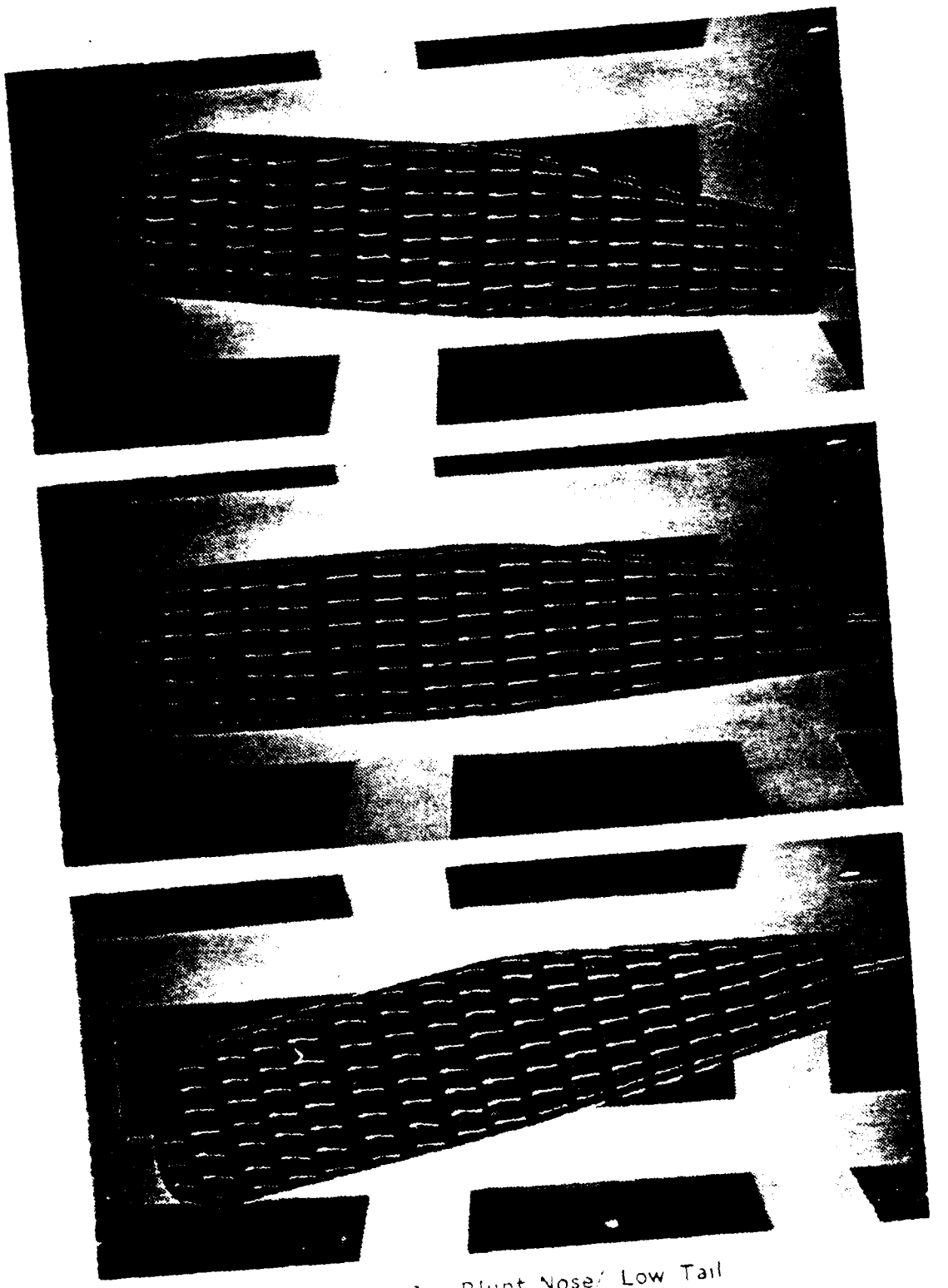


Figure C.6 Blunt Nose/ Low Tail

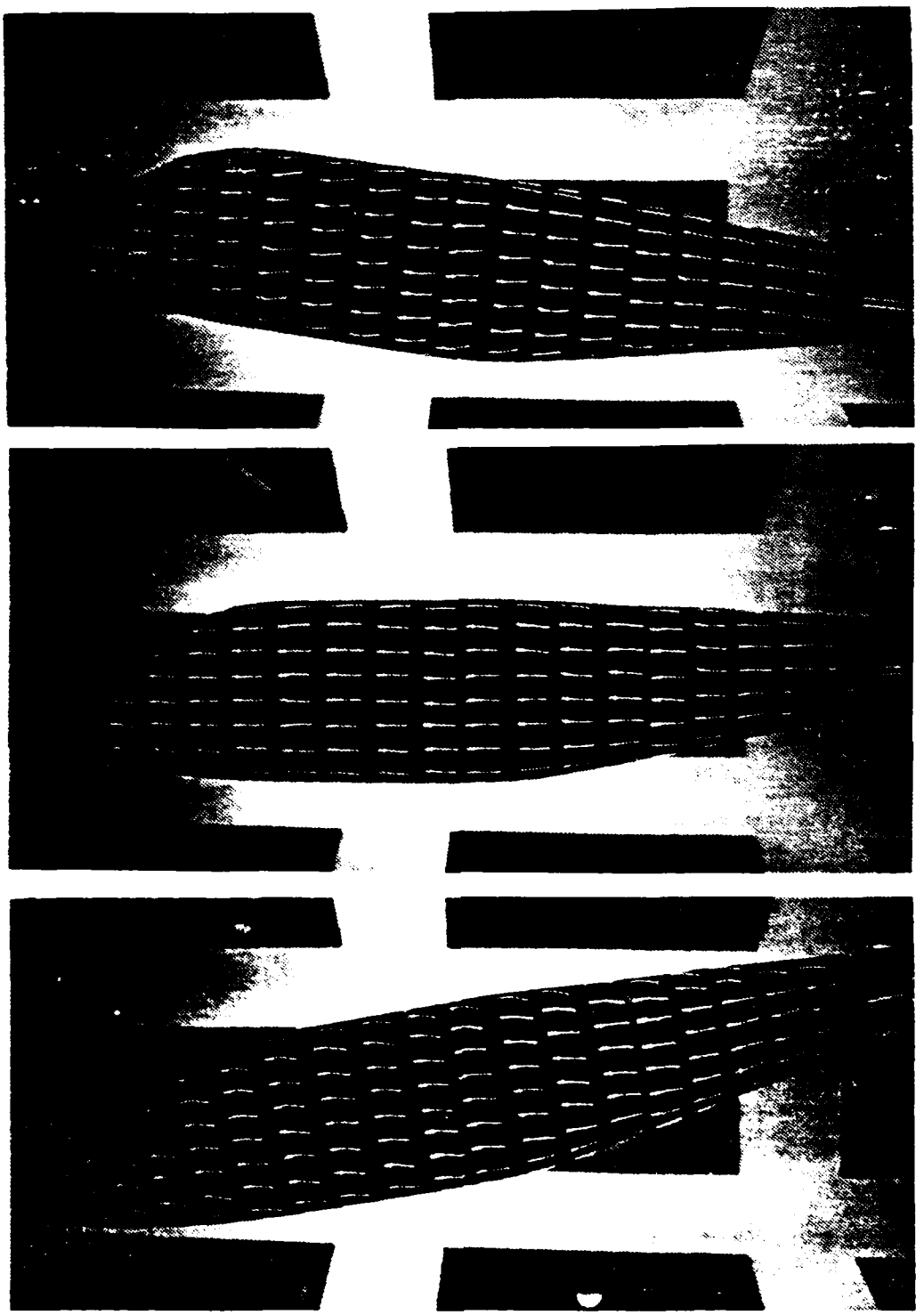


Figure C.7 Smooth Nose High Tail

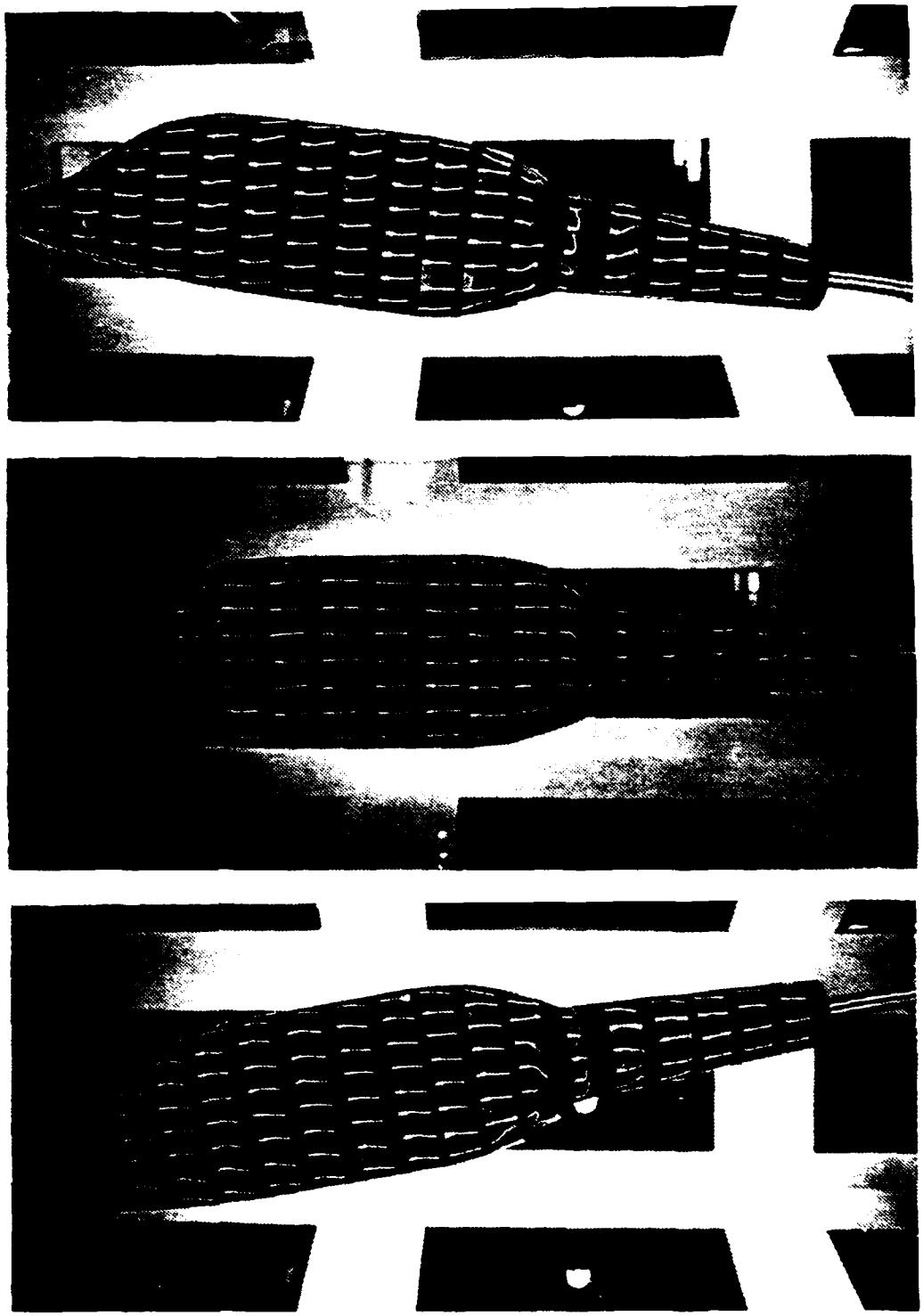


Figure C.8 Smooth Nose/ Symmetric Tail

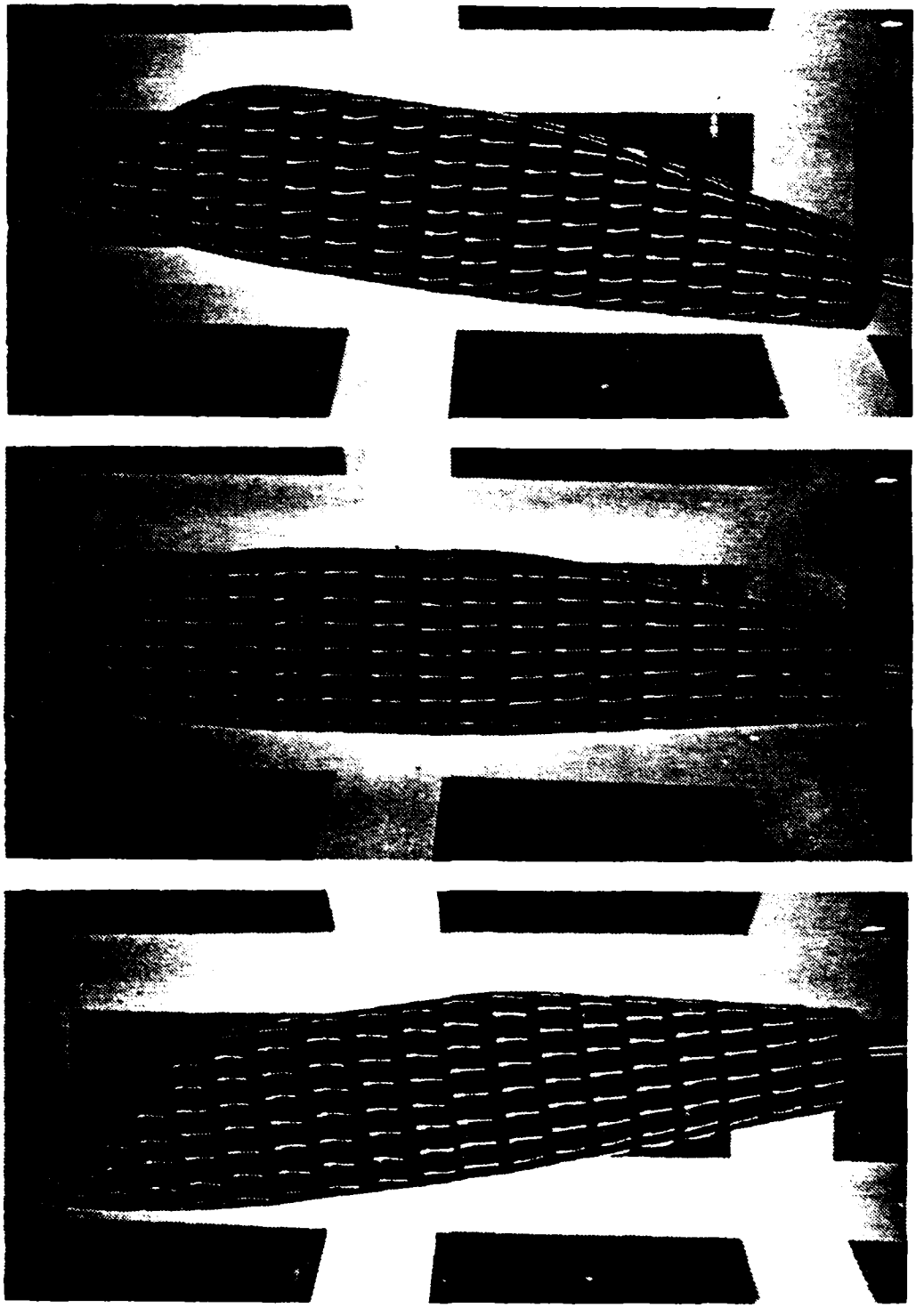


Figure C.9 Smooth Nose/ Low Tail

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